PROVINCE OF QUEBEC, CANADA.

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Department of Colonization, Mines and Fisheries

◆

MINES BRANCH

Honourable HONORÉ MERCIER, Minister :: S. DUFAULT, Deputy-Minister,

THÉO. C. DENIS, Superintendent of Mines

REPORT ON
THE COPPER DEPOSITS
OF THE EASTERN TOWNSHIPS OF THE PROVINCE OF QUEBEC

By J. AUSTEN BANCROFT

QUEBEC,
PRINTED BY E. E. CINQ-MARS,
PRINTER TO HIS MOST EXCELLENT MAJESTY THE KING

1915

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To Mr. Théo. C. Denis,
Superintendent of Mines,
Quebec, P.Q.

Sir,—

I beg to submit the following report on the Copper Deposits of the Eastern Townships, Quebec. This report is the result of about three months and a half of geological field-work: in addition, its preparation has demanded a careful study of the history of the copper mining industry in these Townships.

I have the honour to be,
Sir,
Your obedient servant,

J. AUSTEN BANCROFT.

Montreal, June 25th, 1915.

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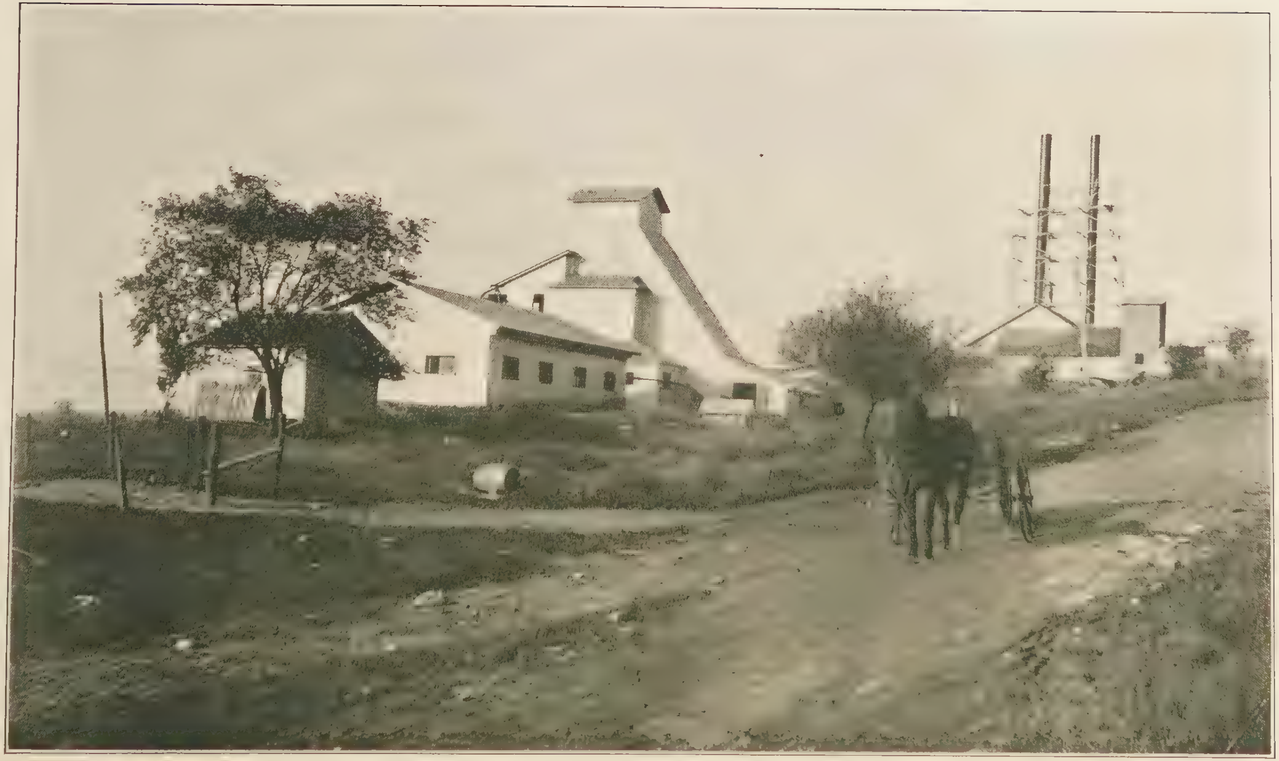

The Weedon or McDonald mine, Range II, lot 22, Weedon township.

THE COPPER DEPOSITS

OF THE

EASTERN TOWNSHIPS OF THE PROVINCE OF QUEBEC

CHAPTER I.

INTRODUCTION

General Statement.

From 1859 to 1866, the Eastern Townships experienced a mining boom during which a vigorous search was made for ores of copper. It was chiefly during this period that the hundreds of prospect-shafts were sunk that are so widely scattered within this area. From a few of these properties very considerable quantities of copper ores were extracted. At the present time, only two copper mines are steadily producing ore, and in large quantities. Of these, the Eustis mine, eight or nine miles south of Sherbrooke, was discovered in 1865; the Weedon or McDonald mine, about five miles by road east of Weedon station (40 miles from Sherbrooke) on the Quebec Central Railway, was discovered in 1909.

Some of the abandoned workings are appropriately called "mines" but a very large number of them to which this term is applied, both in literature and in local conversation, are obviously not in any sense worthy of the name. Frequently it has been said that work was suspended upon a large number of these properties, because of the decline in the price of copper and because of the lack, in the early days, of transportation facilities; that with the present development of railways and improved methods of mining such properties now could be profitably worked provided that a copper smelter be erected at some central point (Sherbrooke or elsewhere), within the area. It has been claimed that the properties now idle could guarantee sufficient ore to keep a large Customs

Smelter and Chemical Works in operation. Often without mentioning chemical works, it has been stated that the construction of a copper smelter would awaken a profitable industry in copper mining, which has been slumbering because the small operators of the idle properties could not afford the transportation charges to centres where such ores are smelted in the United States.

To make a detailed geological examination of many of the occurrences of copper minerals in the Eastern Townships that figure prominently in the literature, and to ascertain, if possible, how many of them could be depended upon to contribute regularly to a copper smelter was the task assigned to the writer by Mr. T. C. Denis, Superintendent of Mines of the Province of Quebec. This report is based upon three and a half months of field work. It includes descriptions of upwards of 150 lots which have been the scenes of either the prospecting for or the mining of copper ores. In the summer of 1913, because of the meeting of the International Geological Congress in Canada, only one month was spent in the field in studying the mines and prospects of Weedon and Stratford townships; a brief preliminary report upon that work has appeared in the "Report on Mining Operations in the Province of Quebec, during the year 1913," pp. 48-54. During July, August and September of 1914, the other properties, described in the present report, were examined.

In addition to field work, the problem in hand demanded a careful study of the history of the operations that have been conducted upon each of the properties. In many instances this history is not as complete as could be desired, but it must be remembered that in this respect, the report reflects the incomplete character of the data to which the writer could gain access. In the hope that it would make this report more valuable for reference, the discussion of each property by the writer is generally preceded by statements of exactly what has been written concerning it in previous reports. Many of what should appropriately be called prospects are still designated as "mines" in this report, merely because the custom of considering them as such has become fixed within these townships. The descriptions of such properties make plain their proper category.

PREVIOUS WORK.

At the close of this report, there is given a bibliography including, in so far as is known to the writer, all of the literature bearing upon the copper deposits of the Eastern Townships, with the exception of certain reports to the directions of mining companies. The names of Sir William Logan, James Richardson, R. W. Ells, J. A. Dresser and A. W. G. Wilson, will always be inseparably connected with our knowledge of the geological relations and character of these deposits. For a comprehensive view concerning their mineralogical character and geological mode of occurrence, anyone interested in the development of these deposits certainly should read the "Report on the Copper Deposits of the Eastern Townships of Quebec with a Review of the Igneous Rocks of the District," by J. A. Dresser, published by the Geological Survey, Ottawa, in 1907.

ACKNOWLEDGMENTS.

The work of the writer was facilitated in many ways by the courtesy of many individuals either engaged or interested in the development of the industry of mining copper and sulphur ores in the Eastern Townships. Thanks are especially due to Mr. L. D. Adams, the General Manager of the Weedon mine, Messrs. L. N. Adsit and J. M. Passow at the Eustis mine, Mr. S. L. Spafford, Superintendent, of the Nicholls Chemical Works at Capelton, Mr. John McDonald, who discovered the Weedon mine, and Mr. John McCaw of the Ascot mine. Grateful acknowledgment is also due to Mr. J. McLeish of the Mines Branch, Department of Mines, Ottawa, who rendered assistance with reference to the Statistics discussed in this report.

CHAPTER II

HISTORY OF COPPER MINING IN THE EASTERN TOWNSHIPS

EARLIEST RECORDS AND DISCOVERIES

In 1842, the Geological Survey of Canada was organized with Mr. (afterwards, in 1856, Sir) William E. Logan as Director. About a year prior to his appointment to this position, Logan examined a copper prospect at Carbuncle mountain, Brompton lake. In the reports of the Geological Survey, the first reference to the occurrence of copper-bearing minerals in the Eastern Townships is contained in his report for 1847-48 in which he states:—"The quantity however appears to be too insignificant in every case to be worthy of further notice, with the exception of *three*, where the ore occurring in veins, bearing the character of regular lodes, seems to be sufficient in amount to justify the risk of small crop trials, notwithstanding that the promise of a profitable result cannot be asserted to be very encouraging."

This statement is followed by a detailed description of the occurrence of some bornite in a quartz vein on the fourth lot of the second range of Inverness, of copper pyrites in a vein of quartz on the seventeenth lot of the seventh range of Ascot, and of copper pyrites in a lode composed of a mixture of quartz and calcite on the fifty-first lot of the twenty-first range of Upton. At each of these localities it was found later that the veins did not carry copper in commercial quantities. In the report of the Geological Survey for 1849-50, Logan mentions the presence of copper ore in two localities in the valley of the Chaudière where "the quantity of copper ore is too small to be available." In the same report he records the opening of a quarry on the fifty-first lot of the twenty-first range of Upton upon the copper-bearing lode to which reference was made in 1847-48. Concerning this deposit he then writes:—"Its irregularities appear too great to render the ore capable of being profitably mined, unless as an adjunct to the quarrying of the rock for the purposes of obtaining materials for building or for burning to lime."

Soon after the appearance of the report of 1847-48, the Megantic Mining Company, which is yet in existence, was formed to work the copper deposits of Inverness and certain copper lands in Halifax and New Ireland townships. As indicative of the optimism that then prevailed, Dr. James Douglas, now of New York, writes:—"My personal recollections are of spending my summer holidays of 1850 at these mines in Inverness. I recollect my father finding one of the shareholders reading by the light of a candle stuck into the blasting powder of an open keg, and another calculating seriously on the best way of disposing of his enormous prospective fortune and deciding on patriotically paying off the British National debt."[1] "The small rich gash veins" then worked in Inverness and later in Leeds "proved too unproductive in quantity to support a mining organization."[1] Until 1856 some mining work was carried on in Inverness; but, because of the discovery of the spectacular ore of the Harvey Hill Copper mine, on the seventeenth lot of the fifteenth range in Leeds, attention was diverted to the latter township.

In 1853, the well known mining and metallurgical expert, the late John Arthur Phillips was sent from England by the firm of John Taylor & Sons to report on the Harvey Hill prospect. In 1856 the Quebec and St. Francis Mining Company was formed to purchase and work the property. In 1858 the English and Canadian Mining Company was organized to operate the mine on a more elaborate scale.

In 1858 also, Mr. Louis Sleeper, of Quebec, commenced work on the celebrated Acton Copper mine, on the thirty-second lot of the third range of Acton. In his report for 1858, Logan[2] describes the geological relations of the Harvey Hill and the Acton mines, and the work that had then been done upon these properties. As an appendix to this report, a list is given of 67 localities where traces of copper were then known to be present in the rocks of Eastern Quebec. This list is accompanied by the wise caution that:—

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[1] Early Copper Mining in Quebec, by Dr. James Douglas, Journ. Can. Min. Institute, 1910, p. 255.

[2] G.S.C. Report of Progress, 1858, pp. 53-63.

"Though most of these may lead to no available deposits, they will yet serve to show the wide distribution of the metal."

An interesting description of the Acton mine by Rev. A. F. Kemp, in the Canadian Naturalist for 1860 (pp. 249-362) portrays its activity at that time. Identical with the experience of today, when a profitable mining centre has been discovered, he relates that:—"Signs of prosperity are everywhere manifest. The barren fields which formerly might have been purchased for an old song are now transformed into town-building lots, and rising enormously in value. According to the course of things in this country the village bids fair to become, ere long, a town and the town, in due course, to be raised to the rank of an incorporated city." His description of the busy scene of active life at the mines is graphic:—"About 200 men, women and boys are engaged in the various departments of the works. The strong men are busy, boring and blasting and carrying off the precious fragments from the mines. Others are breaking the masses of rock into small pieces, and then a multitude of boys and girls are washing, picking and arranging the pieces according to the quantity of copper they contain. Other workmen fill the barrels with the broken, washed and selected ore, and from the mines to the village (a distance of about a half a mile) there is a constant traffic of Canadian carts laden with the metallic spoils."

It is said that, in its time, the Acton mine was the largest copper mine in the world.[1] During the first few weeks of work, in 1859, about 300 tons of ore containing 30 per cent of copper were quarried in open cuts without making much impression on the quantity of ore then in sight.[2] Writing in 1865, Dr. T. Sterry Hunt states that in three years it yielded ores equal to about 1000 tons of copper, but it is now exhausted.[3] In the appendix to the Geological Survey Report for 1866, the more exact information is given that from this mine "16,300 tons of 12 per cent ore have been obtained, dressed, and sent to market, and a great amount of poor ore remains on the surface.[4] From Sept. 1st, 1861, to Sept. 30th, 1862, the mine produced 2,747 tons of 2000 lbs. the average copper content of which amounted to 12 per cent. For the month of October, 1862, the produce was 397 tons of 15.2 per cent; for November, 337 tons of 12.5; and for December, 337 tons of 13.2 per cent.[1]

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[1] Discussion of Dr. Douglas' paper, by J. A. Dresser, Journ. Can. Min. Inst. Vol. XIII, 1910, p. 270.

[2] Catalogue of Economic Minerals of Canada, London Exhibition, 1862, p.12.

[3] Canada. A Geographical, Agricultural and Mineralogical Sketch, 1865, p. 27.

[4] History of the Acton Copper Mine, by Thos. Macfarlane, Can. Naturalist, Dec. 1862, p. 470.

In 1859, the Ascot mine, on the eighth lot of the eighth range of Ascot was discovered and was leased by Mr. Thomas McCaw of Montreal; and in 1861 from a shaft on this property, 33 feet in depth, about 100 tons of eight per cent copper ore had been shipped to Boston. In the fall of 1863, the Ascot mine was purchased by an American Syndicate who erected small furnaces at Lennoxville for the smelting of the ore from this as well as other mines in the province; but in 1864, or 1865, both the Ascot mine and the smelter were closed down.

In 1860 some work had been done on the pyrite deposit, on the twenty-second lot of the first range, north, of Garthby. During 1861, on the property known as Sweet's mine, a shaft had reached a depth of 60 feet. In the same year "five or six small excavations had been made on what is known as the St. Francis Mine on the twenty-fifth lot of the twelfth range of Cleveland, and on the sixth lot of the eleventh range of Melbourne, a shaft of the so-called Coldspring mine had been sunk to a depth of 42 feet. Prospecting work had undoubtedly also been done on other properties.

The Copper Excitement of 1861 to 1866.

The Acton mine proved to be such a phenomenal source of wealth and industry, and the rich ores of the Harvey Hill mine attracted so much attention that prospecting for copper became the order of the day in the Eastern Townships. Shortly after the outbreak of the Civil War in the United States (April 1861 to April, 1865) the price of copper rapidly increased on this continent. This stimulated the prospecting operations to such a degree that great excitement was aroused. Since the majority of the copper mines and prospects of the Eastern Townships, that figure prominently in the subsequent literature, were discovered and worked under the abnormal conditions that prevailed in this period, it is very important to delineate these conditions in some detail.

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[1] Geology of Canada, 1863, p. 716.

The following table shows the fluctuations in the price of copper per pound in the New York Metal market during the years 1860 to 1870:—

	1860		1861		1862		1863	
	High	Low	High	Low	High	Low	High	Low
January	24	23½	20	19	28	27	35	31
February	24	23¾	19½	19	28	25	37	35
March	23¾	23	19¾	19¼	25	23	37	31
April	23½	23	19¾	19	23	21½	31	30
May	23¼	22½	19¾	19½	21½	20¾	30½	30
June	22½	21¾	19	18	23	20¾	30½	30
July	21¾	21½	18	17½	24½	22½	32	29
August	21½	21½	19	17¾	24½	24	31	29
September	22	21¼	20¼	19	27	24¼	32¼	31
October	22	21½	20¼	20	32¾	27	34½	32¼
November	21½	20¼	22½	20¼	32¾	30½	38½	34½
December	20¼	19¾	27	22½	31½	30½	38¾	38½

	1864		1865		1866		1867	
	High	Low	High	Low	High	Low	High	Low
January	41¼	39	50½	46	42	38	29¼	27
February	42	41¼	46	44	38	35½	27¾	27½
March	42½	41½	44½	34	35½	29½	27½	24
April	44	42½	35	34	30	28½	24½	23½
May	44	43	34	30	31	29	24¼	24
June	49	44	30½	28½	33	31	24½	24
July	55	49	30¼	28	33½	31	26	24
August	52½	50	32	30½	31	30	26¼	25¾
September	52½	47½	32¾	31½	31½	30¾	27¼	26¼
October	48	47	33	32½	31	30¾	26¾	22¾
November	49	47	45½	33	30¾	26½	23	22¾
December	50	48½	45½	39¼	29	26½	23	21½

	1868		1869		1870	
	High	Low	High	Low	High	Low
January	23½	21½	26¼	23¾	22	21½
February	24	22½	27	26	21¼	20¾
March	24	23¼	26¾	24	20¾	19
April	24¼	23¼	24	23¼	19¾	19¼
May	24¼	24	24¼	24¾	19½	19
June	24	23¾	23¾	22	20½	19
July	24½	23½	22¼	21¾	20½	20¼
August	24¼	24	23¼	21¾	21¼	20¼
September	24	23¾	23	22	21½	20¾
October	24	23	22¾	22	21¾	21½
November	24	22½	22½	22	23¼	21¾
December	24½	23¾	22	21½	22¾	22¼

For comparison the following figures* showing the average monthly prices per pound of copper in Europe during the years 1862 to 1867, as compiled by Messrs. Vivian, Younger & Bond, London, England, are of considerable interest:—

	1862	1863	1864	1865	1866	1867
January	23.24	21.29	24.59	20.20	21.94	18.03
February	22.16	19.33	24.59	19.33	20.85	17.81
March	21.29	19.33	22.37	19.33	20.85	17.14
April	21.29	19.33	22.37	19.77	19.77	16.72
May	20.20	19.33	21.29	19.33	18.68	17.13
June	20.20	19.33	20.20	18.90	18.68	16.92
July	20.20	19.98	21.29	18.68	18.68	16.72
August	20.20	20.64	21.29	18.68	17.59	16.72
September	21.29	20.64	21.29	18.68	18.68	17.13
October	21.29	21.29	20.20	18.68	18.68	16.48
November	21.29	21.29	20.20	25.20	18.68	16.27
December	21.29	22.37	20.20	23.1	17.59	16.07

It will be observed from the above figures that from November, 1862, to the same month of 1866, the price per pound of copper in

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*Metallgesellschaft, 19th June, 1903-1912, Frankfurt am Main, page 97. These figures have been transformed by me from pounds sterling per gross ton to cents per pound.

New York varied from 28 to 55 cents; and that during 1864, the minimum price was 39 cents in the month of January, while for other months of that year, the minimum prices ranged from 41¼ to 50 cents. It will also be noted that these prices were very far in excess of those prevailing, within the same period, in the European markets.

According to figures compiled from Trade and Navigation returns, and appearing in the Geological Survey report for 1886 (p. 26S) the exports of copper from the Eastern Townships, during this period, were as follows:—

Fiscal year	Value	Fiscal year	Value
1860	$182,112	1865	$ 86,155
1861	230,204	1866	25,109
1862	151,184	1867	145,287
1863	301,362	1868	Quebec and Ontario produced 1394,190
1864	92,048	1869	380,517

From 1860 to 1864 the Acton mine was the chief producer while small shipments of rich ore were made from Harvey Hill. From 1866 to 1869, the Hartford or Lower Canada (now the Eustis) mine, and the Huntingdon mine contributed by far the major portion of this production.

Occasionally statements have been made that during this period, the imposing of import duties on copper ores and smelter products by the United States Government caused the excitement to die down, and many of the "mines" to close. Considering the prices obtained for copper, the duties seem to have been very reasonable for that time. By the tariff act of March 3, 1857, copper ores and copper in pig or bars were admitted into the United States free of duty. This remained in force until the enactment of the act of March 2, 1861, which imposed a duty of five per cent *ad valorem* on copper ores, and of two cents per pound on "copper in pigs, bars, or ingots." By the Act of April 29, 1864, the existing tariff duties, on practically all dutiable materials, including copper ores and their smelter products, were increased 50 per cent for a period of sixty days. The next revision of the tariff, on June 30th, 1864, provided for a duty of 2½ cents per lb. on copper in pigs, bars or ingots, while the five per cent *ad valorem* duty on copper ores continued in force. There was no further change in the rates until with the Act of February 24, 1869, entitled an "Act regulating the duties on imported copper and copper ores" duties were imposed "on all copper imported in the form of ores, three cents on each pound of fine copper contained therein; on all regulus of copper, and on all black or coarse copper, four cents on each pound of fine copper contained therein."

As a consequence of the high price of copper and the comparatively low duty on copper ores during the years 1862-67, it was most natural that attention should be directed towards the Eastern Townships as a district within which it seemed reasonable to expect the discovery of other mines that possibly would be as productive and profitable as the Acton mine. Stimulated by these conditions a rush for copper developed that led to the discovery of very nearly all of the occurrences of copper-bearing minerals that today are known in these townships. Apparently, speculation was then as keen and as injudicious as it has been in some of the more recent rushes to newly discovered mining centres in other parts of Canada. As Ells writes:—"Mines were bought and sold on the flimsiest sort of evidence as to their value or worthlessness; often on samples which were obtained from an entirely different location from that represented." The excitement seems to have been most intense in the years 1862 to 1864. In a report that appeared on November 14th, 1864 on the "Viger Copper Mine," on the eighth lot of the sixth range of Chester, it is stated that:—"Taking advantage of the confidence created by real and valuable discoveries, parties have offered lands as metalliferous, upon which superficial works of exploration had scarcely indicated more than a few slight marks of ore, and imposition of this kind having been resorted to, it was natural that apathy and distrust should have superseded the first impulse in the public mind."

The results of this rush for copper are faithfully reflected in the reports of the Geological Survey for this period. Twenty-eight pages (709-737) of the Geology of Canada, 1863, are devoted by Logan to a description of the copper deposits then known in Eastern Quebec. Even at that date, deposits of copper minerals were known from about thirty townships. Logan's conclusion at that time was that:—"It can hardly be doubted that when the copper deposits of Eastern Canada are thoroughly explored and proper means of working them and of smelting their ores are adopted, they will become a source of great wealth, and furnish employment to a large population."

In the Geological Survey report for 1866 (pp. 28-48) James Richardson amplifies some of the descriptions of properties that appear in the report of 1863, and records some discoveries that had been made in the meantime. As an appendix to this report of 1866, there is a list of upwards of 500 lots in the Eastern Townships on which copper had been discovered. The list is a marvellous tribute to the vigor with which prospecting operations were then carried on. In his report for that year Sir William Logan writes:—"For a knowledge and description of many of the localities, I am indebted to Mr. Charles Robb, Mining Engineer of Montreal, who has supplied me with a list of such as have come under his notice in the course of his professional examinations." The plain statement also accompanies this list that:—"Although sometimes in considerable quantity, the copper ores, in many of the localities here indicated, are met with in traces only." About fifty of the properties mentioned in this list apparently have especial importance lent to them by being designated as "mines," as for example, the Balrath mine, the Short mine, the Magog mine, etc.

From a study of the literature on the subject, and from a comparison of the present condition of the properties with the descriptions given therein, it is evident that from 1867 to 1870, operations were continued on an extremely small number of the properties mentioned in the list of 1866. In 1869, apparently the only properties upon which work continued were the Eustis and Capelton mines in Ascot, the Harvey Hill mine in Leeds, and the Ives and the Huntingdon mines in Bolton. It should be observed that during these years, copper varied in price from 19 to 26¼ cents a pound in New York and it was not until February, 1869, that a duty was imposed of three and four cents respectively, on each pound of fine copper contained in ore, and in matte or precipitate.

As a result of the speculative value of 1861 to 1866, some important deposits of copper ores and of pyrite were discovered. In 1863, the first discovery was made on what is now the property of the Nichols Copper Company at Capelton. In 1865, the first work was done on the adjacent Eustis mine, then known as the Lower Canada mine. In the same year, work commenced on the

Griffiths and the Cillis mines, now known as the Suffield and Howard, on lots 3 and 5, range XI, Ascot. In August 1865, the Huntingdon mine, lot 8, range VIII, Bolton, was discovered, and in 1866 work commenced on the Ives mine, on lot 2, range IX of the same township. Unquestionably, the most important result of the prospecting activity of that period was the discovery of the Eustis and the Capelton mines, six to seven miles southeast of Sherbrooke. These mines have produced large quantities of granular pyrites, carrying low average values in copper and very small amounts of gold and silver. The Eustis mine, which is being worked today at a depth of 3750 feet below the old sills, is estimated to have produced somewhat more than a million tons of this ore.

FROM 1869 TO 1879.

In the report of the Geological Survey for 1872, [1]it is recorded that during the years 1869 to 1871, five copper mines were being operated in the Eastern Townships:— *the Hartford* (now known as the Eustis), then on lot 4, range IX, Ascot; *the Capel*, on lot 3, range VIII, Ascot; *the Huntingdon*, on lot 8, range VIII, Bolton; *the Ives*, on lot 2, range IX, Bolton; and the *Harvey Hill* on lot 17 range XV, Leeds. In 1869, these mines, collectively, gave employment to 342 men and produced 12,800 tons of ore valued at $150,000 at the mines. In 1870, 187 men produced 10,568 tons, valued at $137,447. In 1871, sixty men extracted 3,714 tons which at the mines were valued at $46,370. During 1869 and 1870, five-sixth of the products of these mines were exported to the United States and one-twelfth to England. In 1871, four-fifths of the products were shipped to England and the remainder to the United States.

It would seem that the above figures are low, otherwise it is difficult to harmonize them with those in the Trade and Navigation Returns from 1869 to 1871, where it is stated that the exports of copper from Quebec in 1869 were worth $380,517, in 1870, $269,757 and in 1871, $118,798. It seems even more certain that the mines named were the only ones from which ores were being shipped at this time.

The following statements, including all the information to which the writer had access, show plainly that of the mines then working, the Hartford and the Huntingdon were by far the largest producers. From 1866 to 1871, the Hartford mine produced "not less than 25,000 tons of ore."[1] Up to June, 1869, about 20,000 tons had been smelted on the spot. Apparently in 1871, this mine was closed down. In 1870 the Huntingdon mine yielded 4,500 tons of 12 per cent ore, which for the most part was shipped to Swansea, Wales.[2] From 1869 to 1872, the output of the Harvey Hill mine rose to about 500 tons of concentrates a year. From its discovery in 1866 to the beginning of 1872, 600 tons of twelve per cent ore had been shipped from the Ives mine.

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[1] G.S.C. Report of Progress, 1871-72, p. 148.

The exports of copper, from the Eastern Townships, during 1869 to 1873, as given in the Trade and Navigation returns for these years, were as follows:—[3]

Fiscal year	Value	Fiscal year	Value
1869	$380,517	1872	$102,210
1870	269,757	1873	165,897
1871	118,798		

From statistics of the Customs department, the exports of copper during 1874 to 1879 inclusive were as follows:—

Year	Approximate Copper Content in Pounds	Value
1874	932,866	$111,727
1875	1,782,166	241,439
1876	1,882,491	249,971
1877	1,880,090	245,406
1878	355,160	36,499
1879	408,860	47,817

In the Survey report of 1872, the statement is made that:—"Owing to the low price of copper, these mines have been worked on a very limited scale during the last three years." From 1869 to 1879 the extreme yearly fluctuations in the price (in cents per pound) of copper in New York and London were as follows:—

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[1] Catalogue of Economic Minerals, Philadelphia Exhibition, p. 28.

[2] Footnote in a Report on the Ives mine by Chas. Robb, M.E., 1872.

[3] These figures appear in G.S.C. Report, 1886, pp. 26S-27S. The exports of copper were probably really greater than the figures of the Customs Department represent, as it was found by comparison with the U. S. Treasury Department Returns that for some of the years the copper contents and the declared values in the Canadian Customs Returns of Capelton ores, were too low.

	New York[1]			London[2]	
	Highest	Lowest	Average	Highest	Lowest
1869	27.00	21.5	24.25	.....	.....
1870	23.37	19.00	21.18	.....	.....
1871	27.00	21.25	24.12	18.4	13.86
1872	44.00	27.12	35.36	23.38	16.67
1873	35.00	21.00	28.00	19.92	17.10
1874	25.00	19.00	22.00	19.27	15.81
1875	23.87	21.5	22.68	18.19	17.00
1876	23.25	18.75	21.00	17.67	15.16
1877	20.5	17.5	19.00	16.46	13.64
1878	17.62	15.5	16.56	14.40	11.91
1879	21.75	15.5	18.62	14.61	11.48

The opening of what is to-day known as the *Eustis* mine, then the Lower Canada mine, commenced in the Spring of 1865 and in that year 400 to 500 tons of twelve per cent ore were produced. In the following year under the name of the Hartford mine, it was worked by General Adams of the United States, who, in five years, removed "not less than 25,000 tons of ore." Under his management a furnace was erected about a mile and a half from the mine and up to June 1869, about 20,000 tons of ore had been smelted to 40 per cent regulus on the spot. This regulus was then sent to Bergenport, New Jersey, for further treatment. Anxious to save the sulphur in the ore, General Adams also started a small sulphuric acid works near St. Johns, Quebec; but there was no market for the acid and the project was abandoned. In 1872 the property passed into the possession of the Canadian Copper and Sulphur Company of Glasgow, Scotland. Under the régime of this Company it is known that up to November, 1877, 55,000 to 65,000 tons of ore were taken from the mine. In 1876 it yielded 22,388 tons of ore.

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[1] High and low and average prices of Lake Copper—from the Copper Handbook by W. H. Weed, 1912-13.

[2] Extreme yearly fluctuations of Statement Copper in London—from Metal Statistics, published by The American Metal Market.

Reduction works comprising about 80 burners and 60 furnaces, were erected to treat the ore by Henderson's wet process. It is claimed that, in 1876 from 65 to 70 tons of precipitate, containing 70 to 75 per cent of copper, were produced monthly. From the first of January to the 27th of October, 1877, 13,170 tons (each 2240 lbs.) of ore were mined and treated on the spot; a hundred tons of ore containing 11½ per cent of copper were shipped to England and *1,388 tons of sulphur ore sent to London, Ontario.*

Apparently during at least the major part of 1878 and for a portion of 1879, the mine was closed. In the latter year (1879), the Orford Nickel and Copper Co., later known as the Orford Copper and Sulphur Co., with Major R. G. Leckie as superintendent, leased and reopened the mine. It is said that at that time the Hartford shaft, on lot 4, range IX, about 200 feet north of the boundary with the property of the Orford Nickel and Copper Co. (lots 2 and 3, range IX), had reached the line at a depth of 500 feet on the slope.

The group of mines, frequently called the *Capelton mines* are located on lots 3 and 4, range VIII, township of Ascot. The earliest of these were the Albert (on lot 3, range VIII) and the Capel or Eldorado (S. E. ¼ of lot 4, range IX). When the first discoveries were made in 1863, it is said that these properties were promoted as gold prospects, but as work progressed, the ore bodies proved to be of the type of ore that has since been frequently met with in the Eastern Townships, viz., lenticular veins of granular pyrites carrying variable percentages (usually low) of copper with very small amounts of silver and gold. The Capel mine received its name from the original owner of the property, Mr. George Capel who in company with Messrs. Hunter and Pierce spent from eight to ten thousand dollars in development work. The results of this exploratory work being satisfactory, they divided the property into two portions; the eastern area being called the Albert mine, which soon passed into the possession of a Montreal group, Messrs. W. H. A. Davies and others, who formed the Belvedere Mining Co. In the latter days of 1866, on the Albert property four shafts had been sunk, in one of which at a depth of 121 feet, a cupriferous band possessed a thickness of five feet, of which more than three feet was rich copper ore. At the same time, on the Capel property, a copper-bearing vein had been followed for 300 feet, with a thickness of from 3 to 6 feet.

Soon afterward the property passed into the hands of John Taylor & Sons of London, England, by whom a plant was installed to treat the ore by the Henderson wet process. After a thorough trial, this process failed to give satisfaction and the mines were closed until 1879.

Work began on the *Huntingdon* mine in August, 1865, and by the first of April, 1866, it had produced about 225 tons of eleven per cent hand picked ore, then valued at $45 per ton. Until 1870-71 under the management of Captain Francis Bennett, the production is reported to have been from 200 to 300* tons of ten per cent ore per month. Writing in 1872, Mr. Chas. Robb, M.E., states that:—"Although not over six years since being systematically worked and although the scale of operations has been very limited—owing chiefly to the disadvantage of distance from railway communication and the low price of copper—it has already produced large quantities of ore for the market. During the year 1870 with an average force of not over 40 men and boys, 4500 tons of ore, of from six to twelve per cent produce have been raised and for the most part shipped to Swansea." Although rumored that the mine was not a financial success during the early period of working, it was sold for a large sum of money to a Glasgow Company and the name changed to the Huntingdon Copper and Sulphur Company under the management of Mr. John Rudda, of Cornwall. Under his management, extensive buildings were erected and Ells states that the output was increased to from 400 to 500 tons* of seven per cent ore per month. It is reported that in 1874, large quantities of ore, yielding between 4 and 5 per cent, were mined. In 1872 it was estimated that over 25,000 tons of ore, holding from 3 to 3.5 per cent of copper, were lying at the mine; because of the large admixture of iron pyrites, this ore could not be dressed for shipment, and it was decided to erect works for treating it by the Henderson process. Up to the beginning of 1875, 1500 tons of ore had been reduced, and about $25,000 worth of copper produced. During the first six months of 1875, 4012 tons of ore were treated and 299½ tons of precipitate, containing 75 per cent of copper, obtained and sold for $66,300.

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*As a generalization, these figures are believed to be excessive.

In July, 1875, the reduction works were burned, representing a loss of $75,000; and for the balance of the year, only small quantities of ore were reduced. For a considerable portion of 1876, no mining work was being done but the reduction works were partially rebuilt. In 1877, 1300 tons of ore containing 7 per cent of copper, and 1600 tons in which the proportion would descend to 3½ per cent were mined. The first part was smelted, and the other treated by the wet process; the matte and precipitate obtained were exported to England. The mine was worked in a desultory manner until 1883, when the Glasgow Company finally closed operations. For them, it had not been a profitable venture.

Mining operations commenced at the *Ives mine* in 1866. In February, 1872, it was estimated by Mr. Chas. Robb, M.E., that the total quantity of rock removed from the mine amounted to 6,400 tons of 21 cwt. per ton; and the ore obtained and sent to market at 600 smelter's tons containing twelve per cent of copper. At that time about 35 tons of dressed ore of the same grade, a pile of rock, estimated to yield about 40 tons when dressed, and about 300 tons of "smalls", containing approximately five per cent of copper, had accumulated at the mine. Mr. Robb did not make an estimate concerning a large pile of rock then covered with snow. By May, 1872, when Dr. T. S. Hunt reported on the property, 200 tons of thirteen per cent ore were ready for shipment, and about 2000 tons of rejected ores carrying approximately 4 per cent were in the dumps. Ells reports that the mine closed down in 1876; but a comparison of the underground workings, as they existed in the Galt shaft when re-opened in May, 1911, with the descriptions in Hunt's report (1872) shows that, at least in the Galt shaft, comparatively little work was done after his report appeared.

The *Harvey Hill mine* was discovered about 1850. In 1856, the Quebec and St. Francis Mining Co., was organized to purchase the property and work the mine. So flattering were the results of this company that in 1858, the English and Canadian Mining Company was formed in England, with a capital of £40,000. Each successive report of the English company combined regrets for the past with promises of a successful future. From 1858 to 1864 the following quantities of ore were shipped from the mine:—

In	Tons	Cwts.	Qrs.	Lbs.	Averaging about
1858	9	15	0	2	30%
1859	43	7	0	21	30%
1860	104	5	3	0	30%
1861	70	4	1	6	30%
1862	94	17	2	21	30%
1863	113	20	3	14	26%
1864	235	12	3	3	20%
Making a total of	671	20	2	11	

The mining ton being 21 cwt., or 2,352 lbs. The decrease in the quality of the ore during 1863 and 1864 was attributed to the fact that comparatively small quantities of the ore then shipped were taken from the quartz veins, but chiefly from the cupriferous bands of schist.

Owing to the fact that the original capital of the Company had been all called up, at an Extraordinary General Meeting held on Feb. 28th, 1861, the Directors of the English and Canadian Mining Company were empowered to "raise on mortgage the sum of £8000 to be taken up as the necessities of the Company might require." The report for 1862 brought the discouraging news that £5000 of this money had been spent and that no dividend could be forthcoming "although the indications of mineral wealth still continue to be of a very encouraging nature." A fire at the ore-dressing plant interfered with the shipments. The Company sent out Mr. A. Tregoning who in his report states that "the undertaking is one of considerable merit, and is worthy of vigorous prosecution, aided by an adequate capital."

In the Report of the Directors at the fifth annual general meeting on April 30th, 1863, it was made plain that "The funds at the disposal of your Directors being so nearly exhausted, it has been their study to suspend as far as possible all works not tending to immediate profit". The interesting statement was also made that the net proceeds of sales at Liverpool and Swansea of ores shipped in 1862 amounted to £2,835 9s. 2d.

Exclusive of the original price paid for the mine and of large amounts for surveys and other preliminary expenses, the following items show the amount expended by the Company, in the development of the property to December 31, 1862.

	£.	s.	d.
Cash expended in buildings	1,879	3	10
Salaries	3,081	7	8
Other office expenses	365	8	6
Labor cost	17,468	12	1
Steam engine, apparatus, utensils	1,070	1	4
Oxen, horses, hammers, carts	124	10	5
Metal, fuel, powder, etc	503	3	4
Total	24,491	16	2

"The Englishmen being unwilling to risk more in the venture, some Canadians undertook to pay the Company's debts and buy out the English shareholders. The Canadian Company never had adequate means for prosecuting the work. The old dressing floor had been planned after the oldest English models, using hand jigs and disregarding all labour-saving appliances. The water supply was inadequate and variable, being derived from hillside reservoirs. When the English Company was bought out, it was contemplated to build better works on the Palmer river not more than a mile away; but this reasonable plan was abandoned in favour of the leaching method of Messrs. Whelply and Storer. It was a method based on sound chemical principles, but carried out by the adoption of as many mechanical complications as perverse human ingenuity could devise to frustrate success. Pulverized charcoal was added to the ore to create an intense heat in a shaft furnace where a most moderate heat was required. Storing pulverized charcoal in a room lined with canton flannel is as dangerous as storing lighted matches, and the mill, when it mysteriously caught fire, exploded, rather than burned up, before the process had really had a fair trial."* This disaster, involving an estimated loss of £20,000, occurred in 1866.

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*"Early Copper Mining in the Province of Quebec," by Dr. James Douglas, Journal Canadian Mining Institute, Vo. XIII, 1910, p. 264.

For 1865 the figures for the putput do not appear to be available. For a part of 1866, 265 fathoms of ore were taken from the bed, dressed to 24 per cent and sold in Liverpool for $35,420, at an average of fifteen shillings per unit.

Owing to the fire, operations were suspended until 1869 or 1870, when Dr. James Douglas, sr., took a lease of the property, undertaking to pay $5000 a year and to erect a 50-ton concentrating mill. As Dr. James Douglas, jr., writes:—"His operations under the lease were less unsuccessful than they had been under the old company. The output rose to about 500 tons of concentrates a year and the revenue nearly covered the actual operating expenses. It was, however, a struggle against penury; and while extravagance has wrecked many a mining enterprise, to the shifts and uneconomical expedients, incident to shortness of funds, not a few other failures have been due."

The property promised so well that in 1872, The Consolidated Copper Company of Canada, apparently known also as the Harvey Hill Copper Company was organized in Glasgow, Scotland, to provide a working capital. With the belief that the veins would be continuous and maintain their copper values, Captain Whitburn, the managing superintendent, decided to sink a shaft nearly 2,000 feet distant on the strike from the point the veins had been explored. "The veins were found where expected, but they were barren, and the Company treasury was empty. The Company was wound up in 1879."*

From 1879 to 1889.

In the history of copper mining in the Eastern Townships, the year 1879 was marked by the closing down of the Harvey Hill mine, by the reopening of the Hartford or Crown (now the Eustis) mine by the Orford Nickel and Copper Company, soon afterward known as the Orford Copper and Sulphur Company, and by renewed activity at the Capelton mines with G. H. Nichols & Co., of New York in charge. The period under discussion was also marked by the increasing attention that was given to the sulphur contents of the cupriferous pyrites from these mines.

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*"Early Copper Mining in Quebec," by Dr. James Douglas, Journal of Canadian Mining Institute, Vol. XIII, 1910, p. 265.

During this period, the variations in the prices of copper (in cents per lb.) were as follows:—*

	NEW YORK			LONDON	
	Highest	Lowest	Average	High	Low
1879	21.75	15.50	18.62	14.61	11.48
1880	25.00	17.87	21.43	16.02	11.80
1881	20.37	16.00	18.18	15.70	12.34
1882	20.37	17.87	19.12	15.48	13.64
1883	18.12	14.87	16.50	14.61	12.34
1884	15.00	11.00	13.00	12.56	10.24
1885	11.87	9.80	10.83	10.67	8.48
1886	12.12	10.00	11.06	9.38	8.26
1887	17.75	9.95	13.85	18.36	8.37
1888	17.60	15.85	16.77	21.65	16.05
1889	17.50	11.00	13.49	16.78	8.56

From details furnished by the Customs Department and appearing in the reports of the Geological Survey, the exports of copper from this district during this decade were as follows:—[1]

Year	Pounds	Value
1879	408,860	$47,817
1880	1,434,700	192,171
1881	1,244,780	125,753
1882	1,864,170	182,502
1883	1,400,300	148,709
1884	2,714,400	273,422
1885	2,626,000	262,600
1886	2,736,300	232,855
1887		134,550
1888		257,260
1889		168,457

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*Taken from the Copper Handbook by W. H. Weed, 1912-13.

[1] NOTE.—The exports of copper were probably really greater than these figures represent, as it was found by comparison with U. S. Treasury Department returns that for some of the years the copper contents and the declared values, in the Canadian Customs returns of exports of Capelton ores, were too low.

Statistics concerning the production of copper during 1879 to 1885 do not seem to be available. Those for the remainder of this period are as follows:—

Year	Tons	Approximate Copper Content	Value
1886	43,906	3,340,000	$367,400
1887	38,773	2,937,900	330,514
1888	63,479	5,562,864	927,107
1889		5,315,000	730,813

The figures pertaining to 1884 to 1889 represent the production of the Eustis and the Capelton mines. Practically the same statement applies to the years, 1879-1883; but it is on record that until 1883 work was carried on in a very desultory manner at the Huntingdon mine, and from 1881 to 1883, a few tons of ore were shipped from some other properties. In 1889, the Moulton Hill mine is reported to have produced about 2,000 tons of ore; but the pyrite of this mine did not carry copper values. In 1885, the Eustis mine produced 16,000 tons, while 25,000 tons were taken from the Capelton mines. In 1888, 27,348 tons of ore were shipped from the Eustis, and 1500 tons were burnt in piles, the total production for the year thus amounting to 28,848 tons. In 1889, the output of the Eustis mine was 34,089, including 1,773 tons of matte; of the Capelton mines 36,000 tons. The decline in the production in 1887 was due to the fact that "the largest of the producers, Messrs. G. H. Nichols & Co., were extensively engaged during the year in constructing a new mining plant and sulphuric acid works."

The Orford Copper and Sulphur Company worked the Hartford or Crown mine (which later in this period was called the *Eustis* mine) more extensively than the previous operators. At first they had a lease from the Glasgow Company of the Hartford Shaft and of the old smelting works at Capelton. Subsequently in order to be able to confine their operations to their own lands, a tunnel 1000 feet in length, was driven into the hill at such a level that it meets the old Hartford shaft at a depth of 550 feet. For a time they roasted some of the ore at the Scotch Company's old works, the resulting cinder being smelted in a blast furnace, and some of the copper then refined into ingot. Shortly after 1880 a new smelting plant, including 50 roasting ovens, with a capacity of 1000 tons a month, and two furnaces, was built at Eustis where the concentrating mill now stands. This plant was operated for a few years; but the escaping fumes proved to be so injurious to vegetation that the farmers of the community soon arose in vigorous protest. It is also claimed that the price of copper declined so rapidly from 1882 to 1885 that the smelting operations were unsuccessful from a financial point of view.

In the Canadian Mining Review (February, 1884) it is stated that:—"Hitherto the extraction of copper was the basis of operations at Capelton, and the sulphur was allowed to diffuse itself as dioxide (SO_2) for miles around, injuring the vegetation and otherwise damaging property. If the process were reversed, and the ores were worked for their sulphur, the by-product would become a snug little profit as it is in Europe. The Capelton district could supply a very large demand for sulphur for some time to come, and the ore could be treated either in the immediate locality, or at some other point more convenient for coal and distribution of the raw material." In his report for 1886, Ells writes:—"Attempts were made some years ago to reduce the ore on the spot, and extensive smelting works were erected on the Eustis property at the Crown mine. The experiment, however, was not successful, owing to the rapid decline in the value of copper, and these expensive works are now rapidly falling into ruins. *It seems pretty clearly defined that in the case of the low grade ores, rich in sulphur, such as are found in this section, the only profitable method of handling them is that now adopted, viz., by the utilization primarily of the sulphur.*"

The wisdom of the above remarks is well displayed in the following statistics taken from the Geological Survey reports and showing the increasing tonnage of the ore from the Eustis and Capelton mines that were then shipped to the United States for the manufacture of sulphuric acid. The returns for the copper contents of these ores have appeared on a preceding page, and the values here quoted pertain merely to their sulphur content. The statistics are as follows:—

Year	Tons	Value at the Mines
1881	10,812	$ 48,654
1882	23,980	107,910
1883	25,211	113,449
1884	26,000	117,000
1885	34,123	153,553
1886	42,906	193,077
1887	38,043	171,194
1888	63,479	285,656
1889	72,225	307,292

At the end of 1885, the Crown mine had reached a depth of 1325 feet, and in 1889, of over 1600 feet. In 1886 or 1887 it became known as the Eustis mine, and since that date has been operated by the Eustis Mining Co.

Early in 1886, two shafts, *the "Albert"* and the "*Wheal Betsy*" were being operated at Capelton by G. H. Nichols & Co. The former was 600 feet deep on a vein, then 15 feet wide, that had been followed 200 feet, and was yielding 2,000 tons monthly; while the Betsy shaft was 200 feet in depth on a vein, four feet in width, followed for forty feet. The Betsy was worked to a depth of 250 ft. and was then abandoned. In 1887 this company erected the Chemical Works at Capelton station for the manufacture of sulphuric acid.

In 1889, it constructed works for the manufacture of chemical fertilizers, using 500 tons of Ottawa phosphates during the course of the year.

The years 1881 to 1883, and 1888 to 1889 were marked by a revival of prospecting operations, apparently inspired by the more elaborate working of the Eustis and Capelton mines, and by the erection in 1887, of the Chemical Works at Capelton. The decline in the price of copper during the intervening years, 1884 to 1888, practically caused complete suspension of prospecting effort.

The Sherbrooke Mining and Smelting Company was organized to operate the Ascot, Hepburn and Suffield properties. When emptied of water in 1882, the shaft of the Ascot mine, which had not been worked since 1864, was about 150 feet in depth. In the same year, work progressed on the old Hepburn and Suffield mines, at maximum depths of 156 and 200 feet, respectively. Work on these properties was shortly afterwards suspended; very little, if any, ore having been shipped from them. In 1889, the Ascot mine was again worked to a small extent, and a small shipment made, which carried about 11 per cent in copper.

In 1887, a deposit of pyrite, later known as the Moulton Hill mine, was discovered by a Mr. Burke on lot 23, range III, of Ascot. In 1889, the Grasselli Chemical Company of Cleveland, Ohio, opened up the Moulton Hill mine and also reopened the old Cillis mine, on lot 5, range XI Ascot, under the name of the Howard. Upon these properties, shafts had been sunk to depths of 150 and 200 feet respectively. In this year, about 2000 tons or ore, containing no copper, are said to have been produced from the Moulton Hill property.

About this time, some work was done on the old Sherbrooke mine, lot 12, range VII Ascot, by the Nichols Chemical Company, and about 125 tons of ore were taken to the works at Capelton. Similarly work is said to have been performed on the so-called Parks mine, on lot 12, range VIII, Ascot and the old Belvedere shaft, on lot 10, range IX, was cleaned out and examined. In 1889, the Ascot mine was reopened and a small shipment of ore was made. In 1889, also, some prospecting work is said to have been done on the deposit of pyrite on lot 22, range I. N., Garthby.

In 1881, a prospect shaft on lot 3, range VII, of Ely township, that in 1865 had been sunk 25 feet, was extended to a depth of 55 feet. According to Mr. J. R. Woodward, of Sherbrooke, the owner of the property, ten tons of ore, carrying from 6.6 to 9.2 per cent of copper, were shipped from Acton Station, 18 miles distant before work ceased.

In 1882, three men employed by a New York Company spent more than ten months in removing the water from the Kent shaft of the Harvey Hill mine, by means of a hand windlass. Apparently the mine was then examined but no work done. In 1888, this mine was reopened by the Excelsior Copper Co., of London, England. In four months and a half it is claimed that 520 tons of 20 to 50 per cent ore, and 270 tons of 6 to 25 per cent ore were shipped to England. About 400 tons of ore containing about five per cent of copper were taken from the mine, and with the intention of smelting ore of this lower grade, a crushing and concentrating plant was erected and a small blast furnace was installed. The Quebec Central railway, from which the Harvey Hill mine is seven or eight miles distant, was in operation throughout in 1881. Coke for the blast furnace was brought from Nova Scotia, limestone from Dudswell, Quebec, and magnetite from McVeity's mine, near Kinnear's Mills, Quebec. The venture did not prove to be a financial success. This company also did considerable prospecting work on lot 17, range XIII of Leeds, but did not discover a deposit that could be worked economically. In 1891, the Company was reorganized under the name of the Leeds Copper Co., Limited, but operations of the latter company ceased in 1892.

In 1889, the Lake Memphremagog Mining Co. opened the deposit of pyrrhotite, that carries very low values in copper, on lot 28, range IX of Potton township. An open cut was made and an inclined shaft sunk to a depth of 85 feet from which more than 900 tons of ore were removed, but no shipment was made. No work was done on this property in 1890.

FROM 1889 TO 1909.

In 1889, when the Eustis and Capelton mines had increased their production to approximately 70,000 tons of ore a year, and the Grasselli Chemical Company were engaged in developing their Howard and Moulton Hill properties, the Geological Survey published a report on "The Mineral Resources of Quebec" by Dr. R. W. Ells. To this report, in which twenty-eight pages are devoted to the history of copper mining in the Eastern Townships, the public ever since have turned for detailed information on this subject. That portion of it pertaining to "the Copper Deposits of the Province of Quebec," was reprinted in the Canadian Mining and Mechanical Review for February, March and April, 1891; with a few additions it was also incorporated in the "Bulletin on the ores of Copper in the Provinces of Nova Scotia, New Brunswick and Quebec" issued by the Geological Survey in 1904. Assigned the task of describing the copper prospects and mines of this area and having visited comparatively few of them, Dr. Ells naturally gathered his information from the earlier reports of the Survey and especially from those of 1863 and 1866. Very free use was made of the list of "upwards of 500 localities" in which ores of copper had been met with in the Eastern Townships, that appeared as an appendix to the report of 1866. In this list, the names of the majority of the proprietors, upon whose lots copper-bearing minerals had been found, are given; the caution is also expressed that in many of the localities listed, copper had been "found in traces only." Apparently hoping to safely evade this caution. Ells seems to have based his selection from this list, of the properties to be described or mentioned in his report, upon the relative amounts of space that in 1866 had been given to their description, and to the apparent importance that had been conferred upon some of them by calling them "mines," as, the Belvedere mine, Magog mine, etc. In addition, by following the unfortunate custom, that is even yet prevalent in the Eastern Townships of designating all prospect holes as "mines," Ells gave prominence to more of the properties, by calling them "mines," and by using as prefixes the names of their owners in 1866, as, for example, Lambe and Shepherd's mine, Lord Aylmer's mine, etc. From these points of view, his report is very faithful to the literature to which he had access, even in the repetition of wrong names, or numbers of lots and ranges.

Buried in one of his later geological reports,* which was written after he had visited the occurrences of copper-bearing minerals of the so-called "Sutton belt," Dr. Ells makes the following statement:—"In the northwest portion of the township of Sutton and in the southern portion of Brome, green, chloritic and dioritic rocks contain deposits of copper and iron, the characters of which have been given fully in my report on the "Mineral Resources of Quebec." The mineral-bearing character of these rocks is seen at a number of points thence northward to the St. Francis River, and several mines were at one time located on this belt. These have, however, long since been abandoned; the ore, while being sufficiently rich in copper, not being concentrated in the several lodes in quantity sufficient to repay the cost of its extraction."

In the same year, 1889-1890, the late Mr. J. Obalski,[1] then Mining Engineer of the Quebec government republished with a few additions, the list of 1866 without including the original comments, but prefacing his copy by the statements:—"In the following list will be found indicated all the lots on which copper has to our knowledge been discovered, without stating to what class the ore belongs. Except those afterwards designated, these mines have been abandoned. Nevertheless, many of them are still very rich, and there is no room to doubt that some of them will be again worked to advantage." Later in 1908,[1] Mr. Obalski made the unmodified statement that:—"In the report of the Geological Survey for 1866, about 400 properties are mentioned on which copper has been found and of these only two are actually being worked."

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*G.S.C., Vol. VII, 1894, p. 67J.

[1] Mines and Minerals of Quebec Province, by J. Obalski, 1889-90.

In November, 1902, Mr. J. R. Woodward of Sherbrooke published a "Partial List of Copper and Sulphur Properties in the Eastern Townships of Quebec, from which sufficient ore has been guaranteed to meet Capacity of Custom Smelter and Chemical Works proposed to be established at Sherbrooke, P.Q." This list includes "some seventy mines" that "all lie within a radius of forty miles of Sherbrooke with exception of the Acton, Harvey Hill, Garthby and South Ham mines and numerous mines in Megantic County and Wickham." Mr. Woodward also states that in addition, there are "220 other lots upon which more or less exploration and development work has been done." Much of the information in Woodward's list is taken either from Ells' report or from the Survey Report of 1866; but some properties are added that are not mentioned in the Survey reports, and very considerable information is given that must have been gathered from sources that were extremely unreliable.

In 1907, the Geological Survey published a report on "The Copper Deposits of the Eastern Townships of Quebec with a Review of the Igneous Rocks of the District," by J. A. Dresser. From the point of view of geological modes of occurrence and origin, it is an extremely valuable description of the copper-bearing localities; but the then Acting-Director of the Geological Survey, Dr. Robert Bell, instructed Mr. Dresser not to express any opinion concerning the economic possibilities of individual properties.

Writing in the Canadian Mining Journal for July, 1912, after having briefly reviewed the history of copper mining in the Eastern Townships, Mr. John E. Hardman states that:—"The townships, adjacent to, and surrounding the city of Sherbrooke contain 50 or more properties which either have produced a respectable tonnage, or have shown bodies of ore which have been prospected in part, but have not yet been developed." He concludes that:—"The small venturer in copper mining will not be successful, and it is admitted at once that a large capital is required to make the deposits of Eastern Quebec profitable. The deposits are large enough and extensive enough to justify the investment of large capital and such investment would have a long period of life and a satisfactory profit."

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[1] Mining operations in the Province of Quebec, by J. Obalski, page 8, 1908.

It is to be regretted that the literature upon this subject has evolved unintentionally in such a manner that it has led to the development of misleading opinions concerning the large number of abandoned copper prospects and mines in this district. Although it is unquestionable that in a few instances there may be reasonable hope of the discovery of important ore-bodies in the vicinity of some of the properties previously worked, the reader gains the impression that a large number of these old mines and prospects are only waiting to be reopened and worked under the more favorable conditions of to-day, and that a profit will surely follow. The list of localities where the presence of copper minerals had been observed that appeared in 1866, inadvertently has been diverted from its original intention of merely emphasizing the widespread distribution of traces of these minerals and their constant relation to what was then considered as the middle or Lauzon division of the rocks of the Quebec group.

From 1889 to 1909, the highest and lowest and average prices of Lake Copper (in cents per lb.) in New York, were as follows:—

Year	Highest	Lowest	Average
1889	17.5	11.00	13.49
1890	17.25	14.00	15.60
1891	15.00	10.25	12.76
1892	12.37	10.50	11.56
1893	12.50	9.60	10.75
1894	10.25	9.00	9.52
1895	12.25	9.37	10.73
1896	12.00	9.75	10.98
1897	12.00	10.75	11.36

Year	Highest	Lowest	Average
1898	13.25	11.00	12.05
1899	19.37	13.25	17.76
1900	17.25	16.00	16.65
1901	17.00	13.00	16.72
1902	13.50	11.00	12.16
1903	15.37	12.00	13.72
1904	15.37	12.25	13.01
1905	18.87	15.00	15.89
1906	24.00	17.87	19.61
1907	26.25	12.50	20.00
1908	14.75	12.50	13.50
1909	14.75	12.50	13.48

During these years, according to the Mineral Statistics issued by the Mines Branch, Ottawa, the productions of copper in the ore from this district were as follows:—

Year	Pounds	Value
1889	5,315,000	$730,813
1890	4,710,606	741,920
1891	5,401,704	695,469
1892	4,883,480	564,042
1893	4,468,352	480,348
1894	2,176,430	208,067
1895	2,242,462	241,288
1896	2,407,200	261,903
1897	2,474,970	279,424
1898	2,100,235	225,658
1899	1,632,560	287,494
1900	2,220,000	359,418
1901	1,527,442	246,178
1902	1,640,000	190,666
1903	1,152,000	152,467
1904	1,760,000	97,455
1905	621,243	252,752
1906	1,981,169	381,930
1907	1,517,990	303,659
1908	1,282,024	169,330
1909	1,088,212	141,272

The annual production of cupriferous pyrite, from which the above quantities of copper were derived, was as follows:—*

Calendar year	Tons of 2000 lbs.	Calendar year	Tons of 2000 lbs.
1889	72,225	1900	37,791
1890	49,227	1901	22,732
1891	67,731	1902	31,938
1892	59,770	1903	26,481
1893	58,442	1904	23,729
1894	40,527	1905	28,644
1895	34,198	1906	32,527
1896	33,715	1907	29,574
1897	38,910	1908	26,598
1898	32,218	1909	35,100
1899	27,087		

Apart from minor shipments that were made from a few other properties and the majority of which will be mentioned in the context, the above figures from 1889 to 1907 represent the output of the Eustis and the Capelton mines. For a few months after Aug. 17, 1893, work was suspended in the Capelton mines and they were finally closed down in 1907. The figures for 1908 and 1909 represent the shipments from the Eustis mine. The bulk of the ore produced was shipped to various sulphuric acid manufacturing plants in the United States, smaller quantities being treated at the Nichols' Chemical Works at Capelton.

During this period (1899 to 1909), the Eustis mine worked steadily. For the year ending June 30th, 1890, this mine produced 28,955 gross tons of first grade ore, 3527 tons of fine or second grade ore; of this amount 10,625 gross tons were smelted and 18,328 tons were shipped to points in the United States. Apparently this was the last year in which smelting operations were carried on at Eustis. Writing in June, 1893, Mr. John Blue, then the managing superintendent, stated that "the output of the mine at the present time is at the rate of about 3000 tons of dressed ore per month, and had averaged this quantity for the past year or two." At that time he estimated that:—"Since it was first opened the mine has produced somewhere about a half a million tons of ore, and judging from the general appearance of the vein in the bottom, it will in all likelihood produce as much more, and possibly then be a long way from being worked out." At this time (1893), the mine had reached a depth of over 2000 feet. The decline in the price of copper in 1894 caused both the Eustis and the Albert mines to reduce their staff by more than one half. In 1903 the Eustis Company installed an electrical plant, the power being supplied by falls on the Coaticook river, about two miles from the mine. In 1904, the construction of the crushing and concentrating plant, close to the Boston and Maine railway, was completed.

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*The figures for 1889-1899 are those for "production" being taken from the Mineral Statistics of the Mines Branch, Ottawa; those for 1900-1909 are for "yearly shipments," being taken from the "Mining Operations of Quebec", 1912.

The Capelton mines, with the exception of a few months after August 17, 1893, worked steadily in the Albert and Walter (or Capel) shafts. In 1893, the Albert shaft had reached a depth of 2100 feet on a slope of about 30 degrees, and the Walter shaft was 700 feet deep. Operations ceased in 1907 with the former at a depth of about 2300 feet and the latter a little over 1000 feet. The production during this latter stage in its history was apparently very much less than that of the Eustis mine. During the three or four years prior to being closed down these mines were producing only about 1000 tons of ore a year.

The Nichols' Chemical works at Capelton were operated continuously during this period. In the Mining Operations of the Province of Quebec for 1896 and 1898, Mr. Obalski reports that 9165 tons and 10,372 tons of the copper-bearing pyrite from the mines were treated at these works.

The Huntingdon mine (lot 8, range VIII, Bolton) had not been worked since 1883. Having bought this property in 1888, the G. H. Nicholls Co., carried on prospecting operations during 1892 and 1893. They gained access to the old workings by sinking a new shaft to a depth of about 500 feet. A few carloads of ore were shipped to Capelton and the mine was closed down.

In the year ending June 30th, 1890, the Excelsior Copper Company produced 40 tons of 30 per cent, 60 tons of 17 per cent and 100 tons of 14 per cent copper ore from the Harvey Hill mine (lot 17, range XV, Leeds) In 1891, the Company was reorganized as the Leeds Copper Company of London, England, but their operations ceased in 1892. In September 1895, the property passed into the possession of the Copperfield Mining and Milling Company, in which the late Dr. James Reed seems to have held the controlling interest. This Company worked the property on a small scale until in 1899 the mine was closed and has remained idle ever since. In 1896 and 1897, forty tons of rich and of concentrated ore, carrying about 20 per cent of copper were sent to market. In 1898, no ore was shipped, but in 1899, small shipments carrying about 19 per cent of copper were made. In 1903 two tons of ore were selected and sent to the St. Louis Exhibition.

In the month of July, 1896, the Eustis Company reopened the Hepburn mine (lot 7, range IX, Ascot), that had not been worked since 1892. Work continued during 1897 and possibly for a portion of 1898. This company also did some prospecting work on this property in 1904. In 1909 and 1910 they again reopened the mine. Mr. L. M. Adsit, then Superintendent of the Eustis mine, informs me that they then removed the ore in sight that could be profitably extracted. The mine has been closed since 1910. It is said that the operations of the Eustis Mining Company upon this property have resulted in the extraction of ore in sufficient amount and quality to slightly more than pay their expenditure.

The Ascot mine (lot 8, range VIII, Ascot) was repeatedly opened and closed during this period. In 1897, eight men were engaged in reopening the property for "The Syndicate of Five." During the year 120 tons of ore were extracted and shipped. In 1899 a small shipment of 11 per cent ore was made. From 1901 to 1903, work was resumed on the property by Wilfred Johnston of New York. In 1901, the deepest shaft had then reached a depth of about 250 feet. From 1905 to 1907, mining operations were carried on for eight months, and 150 tons of ore of a good grade (probably 8 to 11 per cent) were produced.

In 1898, some work was done at the Silver Star (then known as the Jackson) mine on lot 4, range XI, Ascot.

From 1901 to 1904 attempts were made in the Eastern Townships to arouse such interest in the old copper mines and prospects that a Customs Smelter would be erected at Sherbrooke. The result was that several old "mines" were cleaned out and some prospecting done at a very few new localities. In 1901, the shafts of the Ely mine (on lot 3, range VII, Ely) which in 1881 possessed a depth of 55 feet was extended to 75 feet. The Balrath mine (on lot

2, range IV, Melbourne) was reopened, but, upon finding no ore, was again closed. In 1901 and 1902, on lot 7, range I, Melbourne, a shaft known as the Bower's mine, was sunk to a depth of 50 feet.

For six or seven years prior to 1910, prospecting work was done by Mr. A. O. Norton at the King mine on lot 4, range XI, Ascot. In January 1906, the old Suffield mine (lots 2 and 3, range XI, Ascot) was reopened by the same gentleman.

In 1906, the old Acton mine at Actonvale was pumped out and some prospecting done.

FROM 1909 TO 1915.

In the history of copper mining in the Eastern Townships, the year, 1909, should always be prominent because of the discovery of the McDonald or Weedon mine on lot 22, range II, of Weedon township, Wolfe County. The rusty appearance of quite extensive outcrops of sericite schist had attracted the attention of prospectors for several years, but no work had been done, because of the prevalent belief that only disseminated particles of pyrite were present in the schists. In the autumn of 1908, Mr. John McDonald of Sherbrooke, purchased the property, and during the following winter and spring, sank several pits in the rusty schists. It was not until the latter part of August, 1909, when, abandoning the rock outcrops, he began to excavate in the bottom of a grass-covered depression, elongated in a direction identical with the strike of the schists, that a body of cupriferous pyrite was discovered. Here, a shaft, 8′ by 8′, penetrated solid ore to a depth of about 25 feet. The property was leased under option to Dr. Pierre de Pierre Ricketts of New York, who later transferred it to the East Canada Smelting Company. According to the agreement of option, this Company paid Mr. McDonald $100,000 for the property.

From 1909 to 1914, the highest, lowest and average prices (in cents per lb.) of Lake copper in New York were as follows:—*

Year	Highest	Lowest	Average
1910........................	14.12	12.50	13.12
1911........................	14.25	12.25	12.77
1912........................	18.00	14.25	16.69
1913........................	17.25	14.50	16.69
1914........................	15.00	11.10	13.50

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*The Copper Handbook, by W. H. Weed.

The first shipment was made from the Weedon mine on August 2nd, 1910, and during the balance of that year 6,112 tons of ore were sent to market. Since that time the shipments (in tons of 2000 lbs.) from this mine, as compared with the total shipments of cupriferous pyrite from this district have been as follows:—

Year	Total shipments from Eastern Townships	Shipments from Weedon mine
1910	24,040	6,112
1911	38,554	23,700
1912	62,107	33,130
1913	87,550	52,000
1914	117,778	59,058
	330,029	174,000

Thus during the past five years, the Weedon mine has produced 174,000 tons of the total of 330,029 tons of cupriferous pyrite that have been shipped from the Eastern Townships.

At intervals, from 1911 to 1914, about 180 tons of copper ore have been shipped from the Ives mine, near Eastman. In 1914, 1600 tons of pyrite, carrying only a trace of copper, were shipped from the deposit near Stratford, six to seven miles from St. Gerard station on the Quebec Central railway. The Eustis mine was the only other property from which ore was exported during this period, so that the amount shipped from the Eustis for the years 1910 to 1914, inclusive, has been about 154,249 tons.

The main ore-body of the Weedon mine* is a lenticular mass of cupriferous pyrite with which very small amounts of galena and zinc blende are associated; it has proved to be 570 feet in length with a maximum thickness of 40 to 45 feet, and striking N 37° E, dips 40° to 45° to the southeast. On the average the north-eastern portion of the lens has been found to carry somewhat higher values in copper than the south-western. Three shafts have been successively sunk on the vein to depths of 96, 350, and 470 feet. At first, the ore was taken by teams from the mine to the railway, a distance of 5 miles, at a cost of about 80 cents per ton. In 1912, a Bleichert aerial tramway, 19,500 feet in length, was constructed from the mine to the railway, at a cost of $1.75 per foot, and the cost of transporting the ore to the railroad thus has been reduced to 6.7 cents per ton. From January 1st to September 1st, 1914, 50,000 tons of ore were shipped, the maximum monthly shipments being those of June and July of 7050 and 7220 tons, respectively. Up to date, the ore has averaged 3.62 per cent of copper, 40.74 per cent of sulphur, 0.77 per cent of zinc, a trace of lead, and 0.46 oz. of silver and .01 oz. of gold per ton. The ore shipped has been sold for about $9.00 a ton, payment being made on the sulphur and copper contents. Following the excellent principle of keeping large reserves in advance of their mining, on September 1st, 1914, they had proved up very nearly 200,000 tons of ore in the mine while from 11,000 to 15,000 tons of broken ore lay in the stopes.

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*See paper on the Weedon or McDonald Copper Mine by L. D. Adams Monthly Bulletin of Can. Min. Institute, February, 1914, pp. 51-62.

At present, the Eustis mine is working at a depth of about 3,750 feet on an average incline of 38°. In 1912, at a depth of 3,450 feet the ore bodies comprised four parallel lenticular veins known as the footwall, the main, the shaft and No. 1 veins. The footwall and shaft veins then carried somewhat better values in copper than the others; but in 1913, the average product of the mine contained slightly less than 2 per cent of copper. At present, work is progressing, at the bottom of the mine, upon two lenticular bodies of ore that average 2 per cent in copper. The maximum capacity of the mine equipment is about 200 tons per shift. The concentrating mill, which has a capacity of from about ten to twelve tons of mill feed per hour, was worked continuously during this period. In 1913, an Elmore oil concentrator was installed.

During 1909 to 1914, development work on a small scale, but more or less continuously, progressed at the Suffield mine on lot 3, range XI, Ascot, one of the properties of Mr. A. O. Norton. No ore was shipped during this period, and upon the outbreak of war, work was suspended, although they were continuing to keep the water out of the mine. In 1910 and 1911, Mr. Norton also removed the water from the old workings of the Marrington mine on lot 6, range IX, of Ascot, but during this time only three tons of ore were sent to market.

In 1910, the Ascot mine had the water removed from it and some sampling was done for the East Canada Smelting Company, but no ore was shipped. In 1913, this mine was again reopened but soon was again permitted to fill with water.

In 1910, as a result of the interest aroused by the discovery of the Weedon mine, a lenticular deposit of pyrite was discovered on lot 8, range VI, S.W. of Stratford township, where in the years 1910 and 1911, an inclined shaft was sunk to a depth of 45 feet in the north-eastern end of the ore body. Four diamond drill holes were also put down and although several feet in thickness of pyrite were penetrated, the copper content of the ore was disappointing to those holding the property in lease at that time. In the summer and autumn of 1914, this property was leased by P. E. Beaudoin of Thetford Mines. The shaft was extended to a depth of 75 feet and in September, at a depth of about 50 feet, they were commencing to drift towards the southwest. About 1600 tons of pyrite carrying on the average from 45 to 48 per cent of sulphur and a mere trace of copper were shipped to the Grasselli Chemical Company's works at Hamilton, Ontario.

The Galt shaft of the old Ives mine, near Eastman, that had been closed since 1876, was reopened in May, 1911, by Messrs. Cromwell and Parker of Eastman. Since then prospecting work has been carried on more or less continuously. The shaft has been sunk from 100 to 180 feet and at this depth a drift extended for 72 feet to the southwest, along a zone of chlorite schists that for a width of four to five feet are traversed, parallel to their schistosity, by veins of chalcopyrite and quartz. Operations ceased a few months prior to the outbreak of the war. Six carloads, of about thirty tons each, have been shipped from the mine; five of these yielded an average copper content of nine and a half per cent, while one carload selected from a portion of one of the old dumps carried five per cent in copper.

In the summer of 1912, Mr. Pierre Tétrault, of Montreal, started to erect a concentrating mill at the Huntingdon mine (lot 8, range VIII, Bolton) with the aim of working over some of the old dumps on that property. The building was completed but the machinery has not been installed. In the spring and early summer of 1914, the water was pumped out of the old Nichols shaft down to about

275 feet. At a depth of 180 feet, some prospecting work was done where they found the schist impregnated with small amounts of chalcopyrite and pyrite, and traversed, parallel to the schistosity by narrow stringers of quartz carrying chalcopyrite. Work was suspended on the property a month or more before the outbreak of the war. Mr. Tétrault has purchased the property from the Nichols' Copper Company.

In 1909, water was removed from the old shaft of the Lake Memphremagog mine (lot 28, range IX, Potton) and about 125 feet north of the open cut a new shaft was sunk to a depth of 80 or 90 feet.

In the fall of 1909, an Allis-Chalmers water jacketed furnace with a capacity of 80 tons per day, was erected at the old Acton mine, lot 32, range III, Acton by Mr. P. Tétrault of Montreal. The plan was to smelt portions of the old dumps at these mines, and to carry on some custom work. About six hundred tons of cupriferous pyrrhotite were brought from the Lake Memphremagog mine; this pyrrhotite was roasted and then mixed with the copper bearing magnesian limestone of Acton. Fifteen hundred tons of ore, selected by hand-picking the old dumps at the Acton mine, are said to have carried about one and a half per cent of copper. After a short run, operations were suspended and have not been renewed. It is certain that none of the dumps at the Acton mine will average a half a per cent in copper. At the Acton mine, black shales lie beneath an upper limestone and rest upon a series of massive limestone beds. The copper ore that was taken from this property in the early days came from the upper limestone and the uppermost portions of the shale in the vicinity of their contact with irregular dyke-like intrusions of a now highly altered diabase or closely allied rock. In 1913, in order to determine the possibility of mineralization of the lower limestone, a diamond drill hole was put down at what was considered to be the most favourable locality on the property; but no evidences of mineralization were found. This work was done under the direction of Prof. J. W. Bell of McGill University.

In addition to the above operations, some prospecting for copper has been done on other properties, but without discovering any deposits of economic value. During portions of the summer of 1914 prospecting work was being performed on lot 6, range VI, of Brompton, on lot 22, range V, of Stoke, on some lots in the vicinity of the deposit of pyrite at Stratford, and some diamond drilling was being done on lot 23, range III, Weedon, but no encouraging results were obtained.

LABOUR.

During the early days of prospecting and mining in the Eastern Townships, labour was cheap. Especially was this true of the period during and immediately after the Civil War (1861-65). At that time, a considerable number of men, chiefly deserters from the army, and locally known as "skidaddlers," crossed the border into Canada. It was a good miner that during that period received $1.00 a day; $1.25 was a very exceptional wage, and many men considered themselves fortunate if they earned 75 to 80 cents a day.

At present, wages are much higher. At the Eustis, a miner receives $1.75 a day; a large proportion of the men are on contract whereby some of them earn $3.00 or more a day. At Weedon, wages seem to be relatively higher. Here, the average daily wage is $2.60. Much of the development work is done under contract at the following rates:—Drifts, 7 x 4, at $6.00 per foot; Raises, 6 x 10, at $4.50 per foot; Winzes, 10 x 5, at $12.50 per foot, and Shafts, 16 x 6, at $25.00 per foot. These prices cover all labour and supplies, except drill repairs, compressed air and drill steel; in raising and drifting, the company does the shovelling.

TRANSPORTATION.

Some of the early mining operations were inconvenienced because of inadequate transportation facilities. The ore and concentrates from the Harvey Hill mine were taken by team to Methot's station *on the Grand Trunk railway, a distance of 21 miles. Writing in 1865, concerning the Harvey Hill mine, Mr. Herbert Williams states that:—"We have paid as high as $10 per ton for the carriage of our ores to Quebec; we now pay $7.00." During the early days of working, the Ives mine and the Huntingdon mine, the products

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*From early reports on the property, it seems that prior to 1863 or 1864, it was necessary to take the ores and concentrates by team to Craig's Road station, a distance of 31 miles.

of these mines were transported by teams to Waterloo, distances of ten and nearly twelve miles respectively. Up to 1870, shipments from the Eustis (then the Lower Canada or Hartford) and the Capelton mines were taken six or seven miles to Lennoxville.

The writer does not pretend to have made an exhaustive study of the history of the transportation but the following statements may prove valuable for reference:

The Grand Trunk railway from Portland through Sherbrooke to St. Lambert was opened in 1853; from Richmond to Quebec in 1854. In 1859, the Victoria Bridge was completed. The then Stanstead, Shefford and Chambly railway from St. Johns through Farnham and Granby to Waterloo was opened in 1858. The latter railway connected at St. Johns with others leading to Boston and New York. It will be observed that the above railways were in operation prior to the activity in prospecting for copper that followed the opening up of the Acton mine.

The present branch of the Boston and Maine Railway that enters Canada through Stanstead to Lennoxville formerly was known as the Connecticut and Passumpsic Rivers Railway; it was chartered in 1862 and the road was opened in 1870.

The Quebec Central Railway was originally organized under the name of the Sherbrooke, Eastern Townships and Kennebec Railway by the provincial legislature in 1868. Work was commenced in 1871 towards building a line to be laid with wooden rails. This, however, was changed for iron rails, and in 1874 the line had been extended from Sherbrooke to Westbury. It was opened to Garthby in 1876, to Coleraine in 1879 and throughout in June, 1881. In March, 1881, the company purchased the Levis and Kennebec Railway, thereby securing an entrance into Quebec. The Tring and Megantic Branch was completed in 1895. A further extension of the line from St. George in the County of Beauce to St. Justine in the county of Dorchester was completed in 1913, and construction work on a further extension of the Branch to English Lake on the boundary between the province of Quebec and the State of Maine is now under way.

The date of the opening of the Southeastern railway from St. Lambert to Richford, Vermont, was not ascertained but it was learned that it was built prior to 1872. The branch line from Sutton

Junction through Actonvale to Drummondville must have been constructed between 1872 and 1880.

In the same period, the Waterloo and Magog Railway was constructed from Waterloo to Magog, and in 1882 or 1883 this line was extended to Sherbrooke.

The Orford Mountain Railway from Eastman northward to Kingsbury was completed on June 30th, 1892. In 1893, it had been extended for a few miles south of Eastman. In 1906, it had reached Potton Springs. Since then it has been constructed northward to meet the Grand Trunk at Windsor Mills, and southward to Mansonville.

The Canadian Pacific Railway now has under its control several of the above roads. On Sept. 1st, 1887, the Southeastern Railway was purchased; on May 24th, 1888, the Waterloo and Magog Railway, and on June 2nd, 1889, the short line through the State of Maine was opened. On March 1st, 1910, this company took over the Orford Mountain line and a few years ago also secured control of the Quebec Central.

Although recognizing that in the early days of copper mining in this district, the lack of transportation facilities was a serious handicap, it should be pointed out that many of the mines and prospects were then as favourably situated with reference to transportation as they are to-day, as for example, those in Acton, Upton, Cleveland and Melbourne townships as well as many in Ascot township and elsewhere. Some of the mines closed down as transportation facilities reached them; many others have been repeatedly opened and closed since the development of the railways.

CHAPTER III.

GENERAL GEOLOGY

The Eastern Townships* include a considerable portion of the truncated complex structures of the Appalachian Mountains in Canada. This complexity of geological relations with which the occurrences of copper-bearing minerals are associated lies to the east of that prominent geological feature known as the Champlain fault, the approximate position of which may be defined as extending from Lake Champlain to the neighborhood of the city of Quebec.

Very little detailed geological work has been done within this large area. Existing geological maps are on a scale of four miles to the inch and are inaccurate. It is an area within which fossils have been found in very few localities, and the tangled, folded and faulted structures of these rocks, giving rise to mountains, have hardly begun to be appreciated. In making an examination of widely scattered copper prospects and mines, one can make but paltry contributions to the broader geological problems of the district. It is plain that even some of the more prominent features produced by folding have not yet been clearly defined as to whether they are anticlines or synclines. Faults, both of the strike and transverse types are of very much more frequent occurrence than has been recognized. In the Summary Report of the Geological Survey for 1913, Dr. Robert Harvie, when describing the stratigraphy of the Sutton anticline mentions the presence of an overthrust fault with a measured throw of 11 miles. Transverse faults striking northwest to southeast and along at least some of which downthrow has taken place toward the northeast, commonly traverse the more prominent ridges.

EARLIER GEOLOGICAL VIEWS.

In reading the earlier geological reports upon this district in the light of the advances that have been made in the subject of geology, one realizes how much at variance our present ideas are with those held firmly by investigators of forty to fifty years ago. Since many quotations concerning individual properties are incorporated in the present report, it is essential that these should be interpreted in terms of our present knowledge. In the Geology of Canada, 1863, p. 735, Sir William Logan writes:—"There appears to be in this region, no facts to sustain the ancient notion of the connection of metalliferous deposits with eruptive rocks which are absent from great portions of the district. The diorites and serpentines of the Quebec group have already been shown to be rocks of sedimentary origin; and the same may be said of the amygdaloids, which are evidently altered argillites. The frequent similarity of these rocks, and of their associated minerals, to the cupriferous strata of the same age on Lake Superior has already been alluded to as a reason for supposing that the copper of the latter region is in no way connected with the intrusive rocks which there accompany it." Again on page 515, he writes as follows:—"The copper of the Quebec group occurs chiefly in interstratified beds. They are often in the limestones of the series, which are generally magnesian, and are frequently associated with serpentines and diorites, both of which also sometimes contain copper. These rocks are accompanied by slates which in many localities are themselves the copper-bearing strata; and in certain parts of their distribution are so much altered as to take the form of chloritic and micaceous schists.....In many parts of the country, the copper-bearing beds are traversed by quartz veins, but these are very often destitute of metal. In other districts, they carry large quantities of very rich ore in a gangue of quartz or of bitter spar, more rarely with orthoclase.....They are seldom continuous for great distances, and the most reliable source of copper in this region has been found in the beds." On page 515 of the Geology of Canada, Sir William Logan makes the statement that:—"The distribution of copper through rocks of the Quebec group is very general, and seems to indicate that this metal was almost everywhere present in the waters from which these strata were deposited."

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*"The Eastern Townships" were surveyed according to the English mode of division of lands in townships that are approximately square, instead of narrow oblong parishes of the French method of survey.

Although Sir William Logan, Mr. James Richardson, and other geologists of that time recognized the presence of some veins of quartz, calcite and dolomite, occasionally with feldspar, containing copper-bearing minerals, they believed that the more frequent and important occurrences of copper ores existed in the form of beds;

that the copper had been deposited from the ancient seas within which these beds were laid down. Moreover they believed serpentines, diorites and amygdaloids to be sedimentary rocks. As a natural sequence they attributed to the copper deposits that regularity and continuity which to a marked degree is a characteristic of bedded deposits. Any irregularities in the mode of occurrence of "the copper beds" was considered as "a twist in the stratification." In reporting on the property of the Ives Mining Company near Eastman in Bolton township, the late Professor E. J. Chapman of the University of Toronto considered that the chlorite and talcose schists containing the copper values were sedimentary rocks and that the same copper-bearing bed undoubtedly carried uniform values in copper and extended from the Galt shaft to the Ferrier shaft, a distance of a half a mile. The late Dr. Sterry Hunt in 1872 points out that the Galt, Brydges and Ferrier shafts of the Ives Mining Company, the Canfield mine and the Huntingdon mine all lie on the same copper belt, "and that judging from the facts before us there is no reason to believe that openings at any other point of the outcrop of about three miles, would not prove as productive as those now mined."

In a similar manner, although some of the copper ore of Harvey Hill was recognized to occur within veins of quartz, it chiefly was considered as being present in beds of nacreous slate. In writing concerning Harvey Hill in 1858, Sir William Logan pointed out that:—"As the copper in the beds is probably contemporaneous with them, it would of course be antecedent to that associated with the courses of quartz, the fissures holding which must have been formed subsequent to the strata in which they occur. The copper in the courses was probably derived from that in the beds."

PRESENT GEOLOGICAL VIEWS.

It was James Douglas, jr. (now Dr. James Douglas of New York) who on Dec. 21st, 1870, presented a paper, entitled "Notes on the Copper Deposits of Harvey Hill," before the Quebec Literary and Historical Society in which he pointed out that the so-called copper-bearing beds vary much in their width and in their copper content. Concerning this deposit, he then came to the conclusion that is believed to-day:—"Strictly speaking, these cupriferous strata do not belong to beds at all, but should be classed as impregnations." This implies that the ores were "deposited subsequently to the formation of the rocks within which it is found." He also concludes that:—"It is more likely that the bed received its copper from the lodes than that the bed fed the lodes."

In 1882, a collection of rocks of doubtful origins from the Eastern Townships were submitted by Dr. Selwyn, then Director of the Geological Survey to Dr. F. D. Adams* for microscopic examination in thin sections. The results of this petrographical study showed the serpentines to be of igneous rocks, being the altered equivalents of peridotites and pyroxenites, while those rocks that were all formerly classed as diorites and also believed to be of sedimentary origin were likewise found to be of igneous origin and to include diabases, gabbros and diorites. In the light of this information, Dr. R. W. Ells was appointed to re-examine the district and his maps resulting from this work display numerous areas underlain by igneous rocks including many of serpentines and "basic eruptives."

The earlier geologists recognized that one of the main geological features within this district consists of the presence of three belts of crystalline rocks that give rise to three ridges which are approximately parallel and trend from the southwest to the northeast. In the southern portions of the area, these ridges are separated by intervening areas, 25 to 30 miles in width, that are underlain by Palaeozoic sedimentary rocks, almost wholly of pre-Devonian age, that locally are intruded by bodies of igneous rocks. These crystalline, and for the most part schistose rocks, continued to be considered by Ells as being chiefly altered sediments of Pre-Cambrian age.

In the course of his work, Dresser found that a very considerable proportion of these so-called altered sediments were in reality metamorphosed igneous rocks:—"The rocks of these belts consist of two parts, one of which is stratified and the other unstratified. The latter is a volcanic rock, finely crystalline, and of both acid and basic phases. Quartz porphyry and andesite, or diabase, would originally have been the extreme types. Some of basic phases are altered to serpentine and all have been highly metamorphosed. It is only by very detailed field study together with microscopic examination that the volcanic character of some of these rocks has been ascertained. Associated with these are stratified rocks of similar material, but which have an original clastic structure. Part contains bands of nearly pure chlorite, abundant quartz veins and much iron ore. These are thought to be stratified tuffs, while other rocks, generally more siliceous, as chloritic sandstones and grauwackes are probably true sediments."

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*Geological Survey Report of Progress for 1880-81-82, pp. 8A-23A.

From the field work and laboratory study connected with the present investigation, the writer is convinced that at least a large portion of what Dresser considered to be highly altered volcanic rocks are in reality the schistose equivalents of fine to medium grained intrusive rocks including the same rock-types which he has described as diabases, porphyrites and quartz porphyries.

To-day, it is known that by far the majority of the copper deposits of the Eastern Townships are associated with more or less highly altered igneous rocks. In no instance can one point to a true bedded deposit. Some of the deposits have been formed through the impregnation or partial replacement of limestones, frequently in the immediate vicinity of hypabyssal or intrusive rocks. A large proportion of the deposits have been formed by the irregular impregnation of the relatively more schistose bands along shear zones within the metamorphosed igneous rocks. In other instances, the schists have been quite completely replaced in such a manner as to give rise to a series of lenticular bodies of ore. Still other deposits have been formed at the contacts of bodies of intrusive igneous rocks. Some are in the form of veins carrying copper minerals in a gangue of quartz, calcite, dolomite, ankerite, occasionally with orthoclase feldspar. In judging the possibilities of these deposits, a complex series of factors enter that would never be considered if they were true bedded deposits.

DISTRIBUTION OF THE COPPER DEPOSITS.

The three belts or ridges of crystalline rocks, mentioned above, have been designated by Dresser as the Sutton belt, the Ascot or Stoke Mountain belt and the Lake Megantic or Boundary belt. The Sutton belt extends to the northeast through the townships of St. Armand, Sutton, Brome, Shefford, Stukely, Ely, Melbourne, Cleveland, Shipton, Tingwick, Arthabaska, Chester, Ham, Wolfestown, Inverness, and Leeds as well as the division of the seigniory of St. Giles, known as the Handkerchief, and Ste. Marguerite, in the county of Lotbinière. The Ascot or Stoke Mountain belt similarly extends through the townships of Hatley, Ascot, Stoke, Dudswell, Weedon, Stratford to Lake St. Francis. Concerning the third belt which lies along the boundary line between Quebec and the State of Maine, to the south and east of Lake Megantic, very little is known.

By far the majority of the known occurrences of copper minerals in the Eastern Townships lie within the Sutton and the Ascot belts. Some, however, are distributed within that area which lies to the west of the Sutton belt and to the east of the Champlain fault. Others are distributed within the area between the Sutton and Ascot belts. It is according to this geographical distribution that the discussion of these deposits has been arranged in the present report.

Copper Deposits West of the Sutton Belt.

Within this portion of the area, the deposits of Upton township, the Acton mine at Actonvale and that deposit which is most frequently referred to in Roxton township were examined. All of these occur in magnesian limestones of Ordovician age, and apparently have been formed by the circulation of copper-bearing waters attending or following the intrusion of dyke-like bodies of diabase and allied rocks. By processes of replacement, the limestone has been irregularly impregnated with chalcopyrite and bornite; narrow stringers of quartz and calcite traversing the limestones also carry small quantities of these ores. At Acton and Upton these stringers also contain a little galena. At the old Acton mine which in its day (1858-1864) produced a large quantity of high grade ore, much bornite and some chalcocite were present. The ore occurred in an upper limestone underlain by dark shale, both of which are intruded by an irregular dyke-like body of diabase. Processes of downward enrichment here apparently assisted in producing rich bodies of ore in the limestone, and when the workings reached the impervious shale, the copper values quite suddenly decreased and could not longer be worked at a profit.

Within this area, previous experience would suggest that it is advisable to prospect the limestones especially in the vicinity of intrusive rocks. That it would also be wise to prospect the intrusive rocks is indicated by descriptions of the occurrences of copper minerals at Drummondville, Nelson and St. Flavien which were not visited by the writer.

Copper Deposits of the Sutton Belt.

The occurrences of copper minerals in Sutton, Brome, Shefford, Stukely, Ely, Melbourne and Cleveland townships were examined. The Harvey Hill Copper mine was also visited.

All of the igneous rocks observed within this belt are now schistose. In their present form of chlorite schists, they are the metamorphic equivalents of fine to medium grained porphyrites, diabases and allied rocks. The schists in this belt strike northeast, and are either vertical or dip steeply to the northwest.

A large number of the deposits in this area appear at the surface as irregular rusty bands of schist within which the schistosity is somewhat better developed than usual. When examined, the schists are found to be very irregularly impregnated with scattered grains of pyrite, chalcopyrite and a little chalcocite. Occasionally these sulphides are present as films or minute veinlets intercalated in the schist. In some localities, parallel mineralized bands are present. In following any of these rusty bands along the strike, they prove to be very variable in width; at one point, they may be a few feet in width, but in a few feet or yards they pinch to a few inches, or they become braided or forked into separate narrow bands, or they taper to a point. Within these mineralized bands, a few irregular parallel stringers of quartz and some carbonate (ankerite, dolomite, calcite), carrying scattered grains of the sulphides mentioned, trend parallel to the schistosity. An individual stringer seldom exceeds a few inches in width, and both in depth or along the strike dies out within a few feet or yards, when another stringer may or may not appear to take its place. Excellent examples of this type of deposit are known under the names of Sweet's mine, range X, lot 8, Sutton; Washer's mine, range IV, lot 2, Brome, and the Shepherd mine (known also as the property of the Canada Copper Mining Company), range V, lot 5, Brome. A man who worked in Sweet's mine (1862-64), and another, who had been engaged at a similar deposit, known as the Pinnacle Mountain mine in St. Armand township that was worked in 1882, informed me that with depth the copper content declined until the schist only carried disseminated iron pyrites with a very few particles of yellow copper (chalcopyrite). This suggests strongly that in deposits of this type, secondary sulphide enrichment has taken place, and that the small amounts of chalcocite and bornite, present in the majority of instances, have resulted from such enrichment. Undoubtedly, the irregular distribution of the copper-bearing minerals and the rapid decline in the copper values at comparatively shallow depths explain why the early work was not continued.

An especially interesting group of deposits are those exemplified by the properties known as the St. Francis mine (range XII, lot 25, Cleveland), the Balrath mine (range IV, lot 2, Melbourne), the Coldspring mine (range II, lot 6, Melbourne), and others. At the St. Francis and the Balrath mines, well-defined veins, and at other localities, irregular stringers of granular calcite, quartz and feldspar (adularia) carry small amounts of chalcocite, bornite, and micaceous specular iron ore. Very rarely a few particles of chalcopyrite are present. At the St. Francis mine much of the vein matter is stained because of the development of a little malachite and azurite; here too, a little chrysocolla and melaconite are present.

The adularia frequently displays a tendency toward the development of perfect crystals. In thin section under the microscope, the adularia is intimately intergrown with the quartz. Some of the feldspar shows faint polysynthetic twinning and probably should be more appropriately called valencianite.

These veins cut chlorite schists, the metamorphic equivalent of a diabase porphyrite or closely allied rock. That in general the veins trend parallel to the schistosity, although in a few instances some stringers ramify in any direction, suggests that they were formed after the schistosity had developed. That subsequently they have been subjected to great pressure is shown, at least in some instances, by the abundant minute planes of shearing that developed parallel to the walls of the vein and, in thin section, by the strong strain shadows in the quartz and the movements of slipping and distortion that have developed along the planes of cleavage in the calcite.

In some localities, in portions of the schists adjacent to veins and veinlets of this type, small nodules of reddish feldspar or of feldspar and quartz have been developed by metasomatic processes. At the

St. Francis mine some of these nodules are an inch in length, and half an inch across; sometimes they are connected by minute reticulating veinlets of quartz and feldspar. Adjacent to such veins, the schists are occasionally impregnated with a few scattered grains of chalcocite and bornite.

Much of the chalcocite and bornite in these veins appear as grains distributed along the minute planes of shearing. In thin sections, small irregular kernels of bornite, within the chalcocite, and thin films of the latter, along cracks in the former, prove that the chalcocite has been deposited later than the bornite from which it, largely if not entirely, has been derived through processes of sulphide enrichment. The bornite likewise may be the result of such enrichment, for its relation to the particles of chalcopyrite, that only were observed in a very few of the fragments on the dump of the St. Francis mine, was not determined; possibly the bornite was derived from the alteration of the chalcopyrite, a very few particles of which were primarily distributed within the vein. At the St. Francis mine, where the largest of the veins of this type occurs, on the southeastern slope of a ridge that almost completely protected it from glacial erosion, at least a portion of the oxidized zone of enrichment was present, as is shown by the presence of azurite, malachite and a little chrysocolla and melaconite.

Veins similar to those just described are classed by Lindgren* among "Deposits formed near the surface." In their mineralogical character, they blend the characteristics of veins and pegmatite dykes. Undoubtedly they have been formed by heated ascending solutions, and subsequently have experienced downward enrichment of copper values.

At what is known as the Grand Trunk mine (range I, lot 6, Stukely) and at the old shaft of the Ely Copper Mining Company (range II, lot 10, Ely) impure crystalline limestones are traversed by a few reticulating stringers of quartz carrying grains of pyrite and chalcopyrite. On the latter property, a very few of these veinlets carry an occasional particle of galena. Through irregular portions of the limestone cut by such quartz stringers, a few grains of pyrite, chalcopyrite and bornite are sparsely disseminated.

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*Mineral Deposits, by Waldemar Lindgren, pp. 434-436.

Copper Deposits between the Sutton and the Ascot Belts.

The known deposits of copper minerals in Bolton, Potton, and Garthby townships, as well as one occurrence in Brompton township were examined. All of these are associated with altered diabases or peridotites, the former usually now schistose, and the latter changed to serpentine. Dr. R. Harvie, of the Geological Survey, Ottawa, has produced evidence to show that at least in Potton and Bolton townships these intrusives are as early in age as pre-Middle Silurian or perhaps older.

Almost all of the deposits known in Bolton township occur near the western margin of an almost continuous but disconnected series of intrusions in the form of large irregular dykes that are arranged along a line striking slightly east of north, and forming the eastern border of the valley of the Mississquoi river. All of these occurrences roughly lie along a line about ten miles in length. The intrusive rock originally varied in composition from a diabase to a peridotite; through processes of metamorphism these rocks have been converted into chlorite and talcose schists and serpentine. All of the copper deposits lie within but near the western contacts of these schistose intrusive rocks, where the schistosity is especially well developed. When traced along the strike, these shear zones narrow and widen in an irregular manner; with depth, they behave similarly. Within these zones, mineralization has taken place; the schists have been impregnated with chalcopyrite and pyrite, and, in some instances, are traversed parallel to their schistosity by veins and stringers of quartz carrying these sulphides. The individual veins and stringers, both with depth and along the strike, pinch and swell, and, within a few feet or yards, usually taper and die out; the mineralizing solutions have filled up the spaces apparently formed by the irregular tearing apart of the schists through shearing. Such veins are very irregularly distributed within the mineralized portions of these highly schistose zones. At the Huntingdon and the Ives mines, and at the Canfield prospect, some pyrrhotite is associated with the chalcopyrite and pyrite; at the Ives mine, there seems to be much less of this mineral than at either of the other properties.

At the Lake Memphremagog (or Smith's) mine (lot 28, range IX, Potton), an irregular series of lenticular bodies of pyrrhotite have developed at the contact between the body of intrusive diabase, that forms Hog's Back mountain, and slates of lower Palaeozoic (probably Ordovician) age. A little chalcopyrite is present, chiefly in the form of thin films upon minute fracture planes in the chalcopyrite. A very few particles of zinc blende also occur in some of the pyrrhotite. When discovered, this deposit was covered with a gossan, several feet in thickness, of limonite. A similar but small and much more irregular deposit of pyrrhotite, carrying an occasional trace of copper is situated on lot 3, range XII of Bolton township.

On lot 6, range IV, Brompton township, a little chalcopyrite is irregularly distributed in small nests or bunches and in grains distributed along a few of the fracture planes in a serpentine.

On lots 22, ranges I. N. and I. S., of Garthby township, a lenticular body of pyrite carrying a trace of copper in the form of chalcopyrite occurs within but near the margin of an intrusion of diabase, which is now in part altered to chlorite schists. The two other occurrences described from Garthby township are narrow and irregular zones of shearing, within which schistosity has been developed, that traverse what is otherwise massive diabase. The schistose bands have been very irregularly impregnated with a little pyrite and chalcopyrite.

Within this area, previous experience demands that in prospecting, the vicinity of the contacts of the intrusive diabases and allied rocks should be carefully examined. If the igneous rocks are schistose, not only their immediate contacts should be examined, but search should be made within the igneous rocks as well.

Copper Deposits of the Ascot or Stoke Mountain Belt.

In reality, this belt embraces two ridges, one of which extends through Hatley, Ascot (where it is crossed by the St. Francis river), and Stoke Townships and into Dudswell Township for a short distance; after a break of three or four miles, the other ridge appears to the east of the St. Francis river and extends from Dudswell through Weedon and Stratford townships to Lake St. Francis. The break between these ridges is chiefly occupied by limestones and shales of Silurian[*] age that underlie a very considerable portion of the comparatively lower land on either side of the St. Francis valley in the townships of Dudswell, Weedon, Garthby and Stratford.

Within those portions of the Ascot belt examined, the rocks are, for the most part, very schistose, having been converted into chlorite and sericite-schists which strike N.E. to S.W. and usually dip from 35 degrees to 50 degrees to the south-east. The schistose equivalents of sedimentary rocks play a very subordinate rôle. The chlorite schists have been derived chiefly by the metamorphism of diabases, porphyrites, fine-grained diorites, or andesites; the sericite schists are the highly altered equivalents of quartz-porphyry. Because of the manner in which these rocks were kneaded together when the schistosity was imposed, their relations are difficult to decipher.

The sericite schists comprise a very condiderable proportion of the ridges of the Ascot belt. They are light grey to pale grayish-green in colour. The less schistose phases of the quartz porphyry display abundant phenocrysts, up to half an inch across, of quartz and of both orthoclase and plagioclase, in a groundmass which when examined in thin section under the microscope is found to consist of an abundance of smaller grains of these minerals with flakes of sericite, a little chlorite, an occasional minute crystal of zircon, a few scattered grains of magnetite or pyrite, and very frequently some carbonate (either calcite, dolomite, or ankerite) and a few very small crystals of rutile. Typical occurrences of the somewhat less schistose and more coarse-grained phases of this rock may be seen in the vicinity of the old Park mine (range VIII, lot 12, Ascot), and at the Silver Star mine (range XI, lot 4, Ascot). An analysis made by Mr. M. F. Connor of the Geological Survey, Ottawa, of a similar rock from the quarry from which road-metal is derived for the city of Sherbrooke is published by Dresser:—

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[*] On a portion of lot 17(a), that is represented upon the existing geological map as being underlain by rocks of Pre-Cambrian age, some poorly preserved fossils were found by the writer in massive beds of gray limestone. These were sent to Professor Charles Schuchert of Yale University who kindly determined them—a small globular *Favosites;* ramose *Favosites* with slender branches; slender *Cladopora; Halysites catenularia,* Linné; large crinoid columnals; an abundance of *Trepostomata,* very much altered, or, a ramose *Stromatoporoid.* Professor Schuchert states that:—"One can certainly say that they are of Middle Silurian age, and probably belong to about the time of the Rochester shale. This find is an interesting one, and with what I know otherwise of the Silurian in Southern Quebec and the New England States, I am coming more and more to the belief that these seas were of wider distribution than I once thought they possibly could be."

SiO_2	70.37	CaO	2.31
TiO_2	.17	Na_2O	2.63
Al_2O_3	11.27	K_2O	1.86
Fe_2O_3	.80	CO_2	3.60
FeO	2.58	H_2O	1.96
MgO	2.03		
			99.58

One may observe every phase from a thoroughly typical quartz-porphyry to silvery-gray sericite-schists in which phenocrysts have been eliminated by processes of crushing and re-crystallization. In some instances, sericite schists, still retaining phenocrysts of quartz and feldspar, appear to pass gradually through chlorite schists, containing similar phenocrysts, into chlorite schists in which no such crystals are discernible. In a few localities, however (as on lots 27 and 28 of ranges III and II, respectively, of Hatley township) the quartz porphyry, in the form of dykes, is plainly intrusive into the rocks of more intermediate composition.

Along the road passing westward from Lennoxville on the western portion of lot 12, range VI, Ascot, the schistose equivalents of fine-to medium-grained diabases or diorites are plainly, and dyke-like bodies of quartz-porphyry are apparently, intrusive into highly altered sediments that appear on the existing geological map as Pre-Cambrian in age. On lots 2, 3, and 4, range XI, Ascot, although the immediate contact between the sericite-schists (quartz porphyry) and the chloritoid-bearing schists (originally, argillaceous sediments) was not observed, the boundary of this contact and the peculiar metamorphism that the latter rocks have experienced, led the writer to conclude that the quartz porphyry bears an intrusive relationship into sedimentary rocks that have been mapped by Dr. Ells as of Cambrian age. These are incongruities that must be clarified by more detailed geological work.

In by far the majority of instances, mineralization is associated with the sericite schists; in a few instances, it has developed at or near their contact with chlorite schists. Upon the wide zone of sericite schists that extends along the western side of the ridge, southward from Sherbrooke, the properties known as the Park, Short, Howard, King, Silver Star and Suffield mines are situated. The Belvidere, the Clark and the Hepburn mines and one shaft of the Sherbrooke mine penetrate sericite schists. The ore-bodies at the Eustis, Capelton, Moulton Hill, and Stratford mines are all enclosed within sericite schists. While at the Weedon mine, the major portion of the ore-body lies in sericite schists, the foot wall of the main ore-body is chlorite schist; here, a few feet within the chlorite schist foot wall, two small ore-bodies are present.

Frequently, where the schistosity is especially well developed, the sericite schists, and, less frequently, the chlorite schists are rusty on exposed surfaces. These rusty bands trend with the schistosity and often, with a length of a hundred feet, more or less, display variations in width of from a few inches to a few yards. This rusty appearance is due to the presence of disseminated grains or crystals of pyrite, occasionally with a few particles of chalcopyrite, and frequently with abundantly scattered grains of dolomite or an iron-bearing carbonate (probably ankerite). The schists are frequently traversed parallel to their schistosity by narrow veins or stringers of quartz, many of which also carry a few scattered grains of the sulphides mentioned. Undoubtedly, the quartz and the carbonates were deposited by the same ascending solutions that carried the sulphides. Some of the veins and stringers enclosed within chlorite schists are chiefly composed of calcite with less quartz and some of the sulphides.

Not only are the more rusty bands of schist heavily impregnated with pyrite and, occasionally, a little chalcopyrite, but narrow parallel stringers, seldom more than small fractions of an inch in width, are also present. The vast majority of these veinlets trend parallel to the schistosity but in a few instances some of them break across from one plane of schistosity to another. For short distances such veinlets may be quite numerous; then long intervals will follow in which few or none of them are present. Where mineralization has advanced to the degree here described, it is quite common to find that shearing processes have been accompanied by local crumpling of the schists.

In a few localities the stringers or veins of sulphide enclosed within the schists assume a maximum width of several inches and a length of several feet; adjacent to these lenticular stringers the schists are more thoroughly mineralized. In such a comparative study, one can observe every stage in the development of the large lenticular bodies of pyrite, the majority of which contain a little chalcopyrite, pyrrhotite, zinc-blende, galena and very low values in silver and gold, that are characteristic of the mines of the Ascot belt.

Both at the Eustis and the Capelton mines these lense-like ore-bodies were found to be arranged *en échelon*. At the Eustis mine, none of the individual lenses of ore have exceeded 350 feet in length on the strike while some of them have attained a thickness of 60 feet or more. The Weedon ore-body possesses the largest dimensions of any single lens that, as yet, has been discovered in the district; it is 570 feet long and about 50 feet in maximum thickness. With depth, these lenticular ore-bodies narrow and swell and, at some places, practically pinch out; at the Eustis mine, the largest single lens possessed a length on the dip of 800 feet. Frequently ore-bodies of this type overlap; occasionally, parallel ones are present. At the Eustis mine they are arranged in such a manner that if work is progressing upon what is known to be the extreme foot-wall lens of ore and it becomes exhausted, the miners drift a few feet to the northeast, and cut into the hanging wall in order to find the next lens. When the Eustis mine was working at a depth of 3,450 feet on the incline, four parallel lenses were present. This is a type of deposit where diamond drilling must be done in order to avoid the possibility of neglecting ore that may lie but a few feet removed from the vein upon which work is being carried on.

With depth, the dip of the schists frequently varies from 25 degrees to 70 degrees. So, likewise, the ore-bodies pitch and flatten in sympathy with the "rolls" or waves of the schist.

The walls of the ore-bodies are not sharply defined; they pass very gradually into schist containing less and less of the sulphides. In general, the zone of disseminated sulphides extends farther into the hanging than into the foot wall. Occasionally, curtains or horses of schist are enclosed within the ore; their marginal portions are always heavily impregnated with ore.

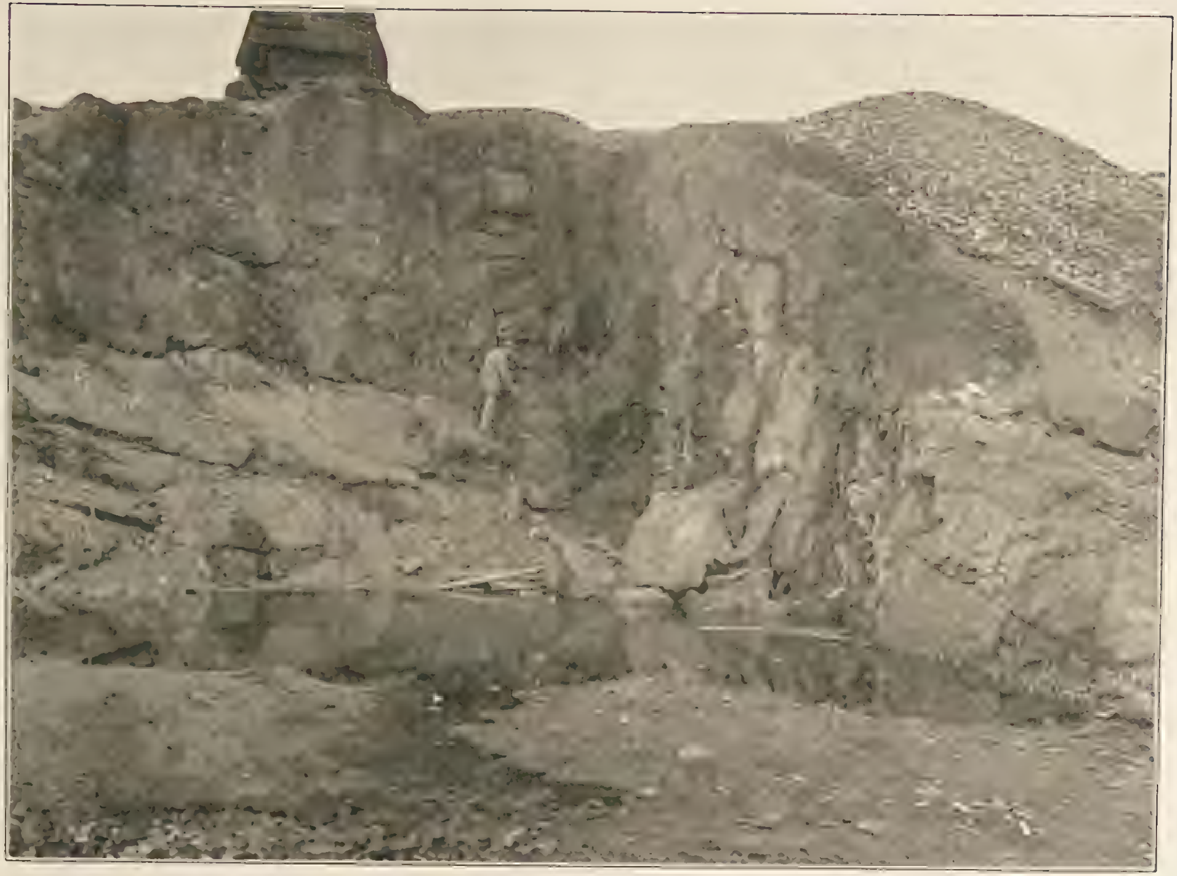
The copper content of these ores is very variable. At the Eustis mine the copper values in a single ore-lens are usually higher toward the foot wall and, less frequently, near the hanging wall; the average copper content of one lens is no index of what that of the next will be. In all of the localities where this type of ore-body carries copper, not only is the chalcopyrite irregularly distributed through the pyrite, but it appears as irregular streaks within the pyrite. That this was not produced by descending waters apparently is proved definitely by the fact that at depths of 700 to 800 feet, the Eustis mine is very dry, and yet at a depth of 3,750 feet, on the incline, where water must be carried down for the drills, such streaks of chalcopyrite are present in the ore.

A few specimens of what would appear to be solid sulphide ore, taken from different mines in the district, were examined in thin section under the microscope. Invariably they were found to contain one and usually two or more of the following non-metallic minerals—quartz, sericite, chlorite, some carbonate (usually dolomite, or ankerite) and in one instance a pale hornblende was present in considerable amount. Of the sulphides, the pyrite has been developed first, and is usually followed in order by a little zinc blende, galena, pyrrhotite and chalcopyrite.

Study in the field and with the petrographical microscope shows plainly that these ore-bodies have been formed by processes of replacement. In the sericite schists, especially the feldspars and quartz have been replaced by the sulphides. Occasionally one may see a banding in the ore which displays the original crumpling of the schist. At the Eustis mine, this is also seen in the so-called "green-rock" which is as truly vein material as the solid sulphide ore. Under the microscope the massive green-rock is found to consist of an abundance of dolomite or ankerite with very considerable sericite, quartz, crystals and grains of pyrite and numerous minute prismatic crystals of rutile. A series of specimens easily may be collected to show the progressive replacement of the sericite schist into "green-rock" which often retains with precision the crenulations of the schist.

Apparently mineralization took place either after or during the time when the rocks were being rendered schistose. The ore-bodies developed by replacement of the schists, through the action of solu-

Pl. II



Olivine-diabase dyke, at site of old mill of the Howard mine, Range XI, lot 5, Ascot township.

tions ascending at favourable points along zones where shearing processes had developed intense schistosity; the shearing was accompanied by a strong tendency to overthrusting as is shown by the crumpling of the schists. Since the ore-bodies were formed, they and the rocks that contain them have been subjected to pressure; this is shown by the local brecciation of the ore. Although the sulphides are most frequently associated with the schistose quartz porphyries, there are sufficient instances where they occur with the metamorphic equivalents of diabases, fine grained diorites, etc., to show that the ore is not genetically confined to the porphyries. It seems possible that the brittle quartz-porphyries developed more readily the degree and character of schistosity that would permit the passage of mineralizing solutions. The associations of these ore-deposits suggest the conclusion reached by Dresser that the source of these sulphide ores seems to have been the schistose igneous rocks.

Subsequent to the development of the ore bodies, the district has been traversed by faults, by far the majority of which strike north of west with downthrows toward the north. Several of these have been encountered in the Eustis mine, the most important of which had a downthrow of 60 feet, casting the ore into the hanging wall. Similar faults have been met with in the Suffield, Howard, Capelton and Moulton Hill mines.

In that portion of the Ascot belt to the south of Sherbrooke, dykes traverse the schists and ore-bodies. These dykes display no evidence of having been subjected to pressure. They include camptonites, monchiquites and other rock-types identical with those from dykes in the vicinity of Mount Royal at Montreal and other of the Monteregian Hills. Specimens of two of the dykes in the Eustis mine were examined in thin sections—one proved to be an augite monchiquite, the other which was very coarse in grain proved to be very similar in composition to some phases of the essexite at Montreal. A dyke of hornblende camptonite was met with in a shaft on lot 27, range I, Hatley. At the Howard mine a large dyke of olivine-diabase is exposed at the site where the old concentrating mill stood. Similar dykes were present in the Capelton mines. In all instances, the ore-bodies are cut by the dykes immediately adjacent to which the ore is usually somewhat higher in copper. The dykes plainly bear no genetic relationship to the ore but the heated waters attending their intrusion have gathered some of the chalcopyrite in the ore and re-deposited it in the vicinity of their contacts. If, as seems probable, these dykes were injected at the same time as the igneous rocks of the Monteregian Hills, they are of an age definitely later than the Lower Devonian, and probably belong to the late Devonian or early Carboniferous period.

Both at Weedon and Stratford, the ore-bodies are dipping towards a batholith of granite the margin of which in each locality is from 900 to 1000 feet* removed at right angles to their strike and that of the schists into which the granite is intrusive. In both localities, the granite, for some distance from its contact, displays pegmatitic tendencies, being quite coarse and variable in grain, while the main portion of the mass is biotite-granite of uniform texture. Even where of normal granitoid character, muscovite is often more abundant toward the periphery than toward the interior of the intrusion. The very rusty character of the schists in contact with the more pegmatitic phases of the granite at first led the writer to the belief that the granite was genetically related to these sulphide ore-bodies. During the past summer, an aplite dyke, 6 inches wide, was encountered in the Weedon mine which cuts the lower portion of the ore-body. The aplite is perfectly fresh, yet adjacent to it, copper values are somewhat higher than usual; even on the joint planes in the granite thin films of chalcopyrite, with a little zinc blende and galena, have been deposited. It now seems probable that the ore-bodies were formed prior to the intrusion of the granite, but the heated waters and vapors attending the advance of the batholith have more or less rearranged the sulphides previously present in the schists. In this sense, the part that the granite has played would be analogous to the dykes of camptonite, monchiquite, etc., at the Eustis and Capelton mines.

In the Ascot or Stoke Mountain belt, all of the schistose igneous rocks and especially the sericite schists should be carefully and systematically prospected.

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*The only geological map that exists of this area was published in 1886 on a scale of four miles to the inch, by the Geological Survey of Canada. Upon this map, schistose Pre-Cambrian rocks and Ordovician sediments are represented as occupying that portion of the area where the corners of Weedon, Lingwick, Stratford and Winslow townships meet, whereas in reality, there is here a body of granite which occupies at least 15 or 16 square miles, forming prominent hills that, locally, are referred to as "The Block."

CHAPTER IV.

CONCLUSIONS.

The following conclusions pertain especially to the industrial development of these copper deposits. Although they include the unpleasant task of dispelling certain illusions, it is hoped that they may prevent unnecessary losses, and at the same time, that they may lead to the forming of a sound basis for industry.

An analytical study of the history of the copper deposits of the Eastern Townships, and a geological examination of those properties described in this report have led to the following conclusions:—

(1). It is to be regretted that the statement has repeatedly appeared, without qualification, in literature and frequently is heard in conversation that the copper mines and prospects now idle throughout these townships were closed down because of the decline in the price of copper. During the Civil War in the United States (April, 1861 to April, 1865) the price of copper experienced a sensational rise upon this continent. Whereas in 1861, in the New York Metal Market, it was selling for 17½ to 22½ cents a pound, in 1864 it varied in price from 39 to 55 cents. It was not until 1868 that prices practically returned to what they had been prior to the war. It was during this period (1861-66) of abnormal prices that the vast majority of the occurrences of copper in the Eastern Townships were exploited. In 1869, only five mines continued to be worked—the Capel, the Eustis (then the Hartford), the Harvey Hill, the Ives and the Huntingdon. Rather than attributing the closing down of the other properties to the decline in the price of copper, *it should be pointed out that it was due to the abnormal increase in the price of copper that the most of them were opened.*

(2). It is unfair to say that the imposition of duties on copper and on copper ores shipped to the United States was a factor in the early suspension of work upon these copper properties. It was not until February, 1869, that for a few years the United States government placed a duty of three cents on each pound of fine copper contained in imported copper ores, and four cents on each pound of fine copper contained in all regulus of copper and in all black or coarse copper. At the time this tariff was established, five mines were working—the Capel, the Hartford (now the Eustis), the Harvey Hill, the Ives and the Huntingdon.

(3). At the time when this early work was done, labour was very much cheaper than now. Labourers then (1861 to 1866) usually received from 75 cents to a dollar a day; $1.25 was an exceptional wage. At the Weedon mine, the average daily wage is now $2.60 a day. At the Eustis mine, a miner receives $1.75 a day, but the majority of the miners are on contracts whereby they make considerably more money.

(4). During the early days, the lack of transportation facilities and the higher freight rates then in vogue, proved to be a very serious handicap to the successful working of some of the properties and the development of others. For example, it would seem that under good management and with the railway facilities of today, the earlier days of working the Harvey Hill, the Ives and the Huntingdon mines should have proved to be profitable. On the other hand, the railways were then as close to very many of the prospects and mines as they are today. This is true of the points where work was done in Upton, Acton, Durham, Cleveland, Melbourne, Shipton, Tingwick and Chester townships, as well as individual properties in other townships. At the time when the large number of properties in Ascot township were opened, the Grand Trunk Railway passed through Sherbrooke and Lennoxville. In 1870, what is now the Boston and Maine Railway was opened from Lennoxville southward through Capelton, Eustis and Stanstead.

(5). A large number of properties now idle have been repeatedly reopened since the development of the present railway facilities.

(6). Four copper mines in the Eastern Townships undoubtedly have yielded large profits to their owners. These are the Acton mine at Actonvale, the Eustis and Capelton mines in Ascot township, and the Weedon mine in Weedon township. From 1858 to 1864, the Acton mine is said to have produced 16,300 tons of ore that would average 12 per cent in copper. Since 1909, the Weedon mine (to May 1st, 1915) has produced 205,000 tons of ore carrying on the average 3.62 per cent of copper, 40.74 per cent of sulphur, gold 0.01 oz. and silver 0.46 oz. This ore has sold for about $9.00 a ton, payment being made on copper and sulphur. The Eustis mine has been worked continuously since 1879; prior to 1879, 80,000 to 90,000 tons of ore were produced. It seems certain that from the Eustis mine more than a million tons of ore have been extracted. Its copper content has varied; at present its ore carries on the average about 2 per cent of copper, 42 per cent in sulphur, and two ounces in silver and a few cents in gold, per ton. No data have been published concerning the production of the Capelton mines owned by the Nichols Copper Company.

The ore extracted from the Hepburn mine (lot 7, range IX, Ascot) is said to have slightly more than repaid the Eustis Mining Company for their expenditure. It seems very doubtful if their profits from this property have been sufficient to cover the expense of the earlier work performed upon it by other parties.

As yet, the profits derived from the tonnage of pyrite, shipped from the Stratford deposit, has not equalled the expenditure connected with the earlier exploratory work on the property.

It does not seem at all probable that the ores taken from any of the other properties described in this report have repaid the money that has been spent upon them.

(7). It is to be regretted that much of the literature concerning these copper deposits has been accumulated in such a manner as to create and repeat misleading impressions. For an explanation of this statement the reader is advised to consult Chapter II of this report, under the heading "From 1889 to 1909." For an example,—it is somewhat disconcerting to find that of the "thirteen mines," mentioned by Ells,* that "were operated" in Ascot township up to 1865, only three have been worked at a profit; at least four or five of them never shipped any ore, and that on one of the properties, no opening was made in the bed-rock.

(8). The earlier geologists considered many of these deposits as being of sedimentary origin, and attributed to them that uniformity and continuity that characterizes bedded deposits. Even in 1904, Dr. R. W. Ells repeated what in 1888-89 he had written concerning the deposits of Ascot township:—"In view of the fact that these several ore-beds, which are found over a breadth of some three to four miles, resemble each other very closely, and from the crumpled and overturned character of much of the strata in which they are contained, it seems most reasonable to suppose that the greater part of these mines were located upon different portions of the same lode, repeated by folding from place to place". . . . Today it is known that the majority of these deposits are associated with intrusive igneous rocks and their schistose equivalents. *No true bedded deposits are present.* A few of the ore-bodies occur in the form of veins; but the majority are either impregnations, replacements or contact deposits.

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*R. W. Ells in G.S.C., Vol. IV, 1888-89, p. 50K.

(9). The vast majority of the prospects and "mines" in the district that are now idle are in their present condition because: (a) The finding of a few particles, or even some good specimens of copper ores does not signify that a profitable deposit has been discovered. (b) In some instances, because of processes of secondary sulphide enrichment, the ore was quite rich at the surface, and at comparatively shallow depths became so low in grade as to be unprofitable to work. Not realizing the cause for the decrease in the copper content, the operators continued work in the vain hope that, with depth, better results would be obtained. This is especially true of some of the properties of the Sutton belt. (c) In the Ascot belt, in a considerable number of instances work has progressed upon lenticular bodies of grayish to jasper-like, granular quartz* cut by reticulating stringers of milky-white quartz carrying some flakes of micaceous specular iron ore. (Plate III). The granular quartz carries very widely scattered grains of pyrite, occasionally a very few particles of chalcopyrite, and sometimes is intersected by minute irregular veinlets of pyrite. Much work has been performed in the vain hope that with depth such deposits would prove to be valuable.

(10). The most common type of deposit occurs in the form of lenticular bodies of pyrite carrying a little chalcopyrite, frequently with very small quantities of zinc blende and galena, and very low values in silver and gold. These lenticular bodies of ore are enclosed in schistose igneous rocks; of very variable proportions, they are arranged *en échelon.* Frequently, they overlap; occasionally, parallel bodies are separated by a few feet of schist. In the Ascot belt, the majority of these lenses of ore lie within sericite schists,

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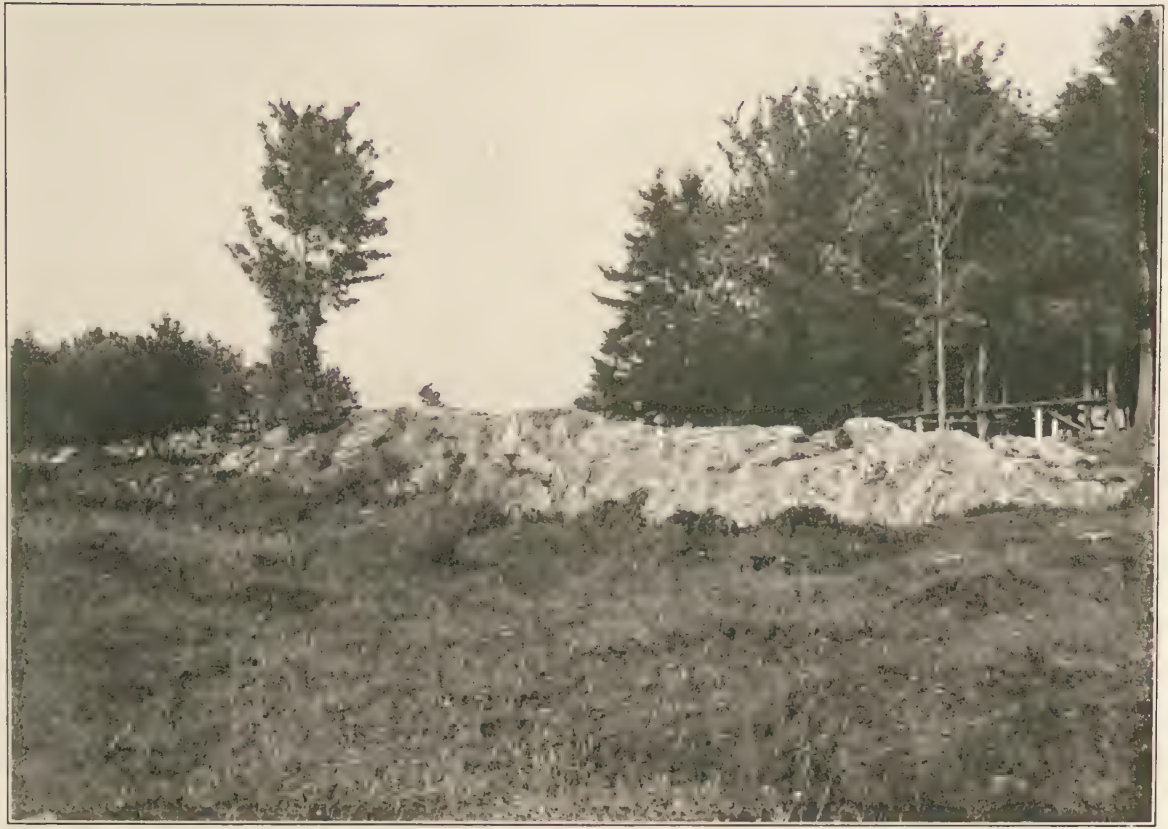
*Upon such lenticular veins of quartz, work has been done on lot 21, range VI; lot 5, range IX, lot 1, range X; lot, 1, range XI in Ascot township, and on lots 38 and 39, range II, S. W. of Stratford township.

Pl. III



Lenticular vein of granular, greyish to jasper-like quartz enclosed in chlorite schists. Range VI, lot 21, Ascot township.

the metamorphic equivalents of a very acid quartz porphyry. It seems probable that a few of the now idle properties were shut down because, in each instance, the lenticular body of ore, upon which work progressed, practically pinched out, and little, if any, intelligent search was made for another ore-body. Until the presence of other lenticular bodies of ore be proved, such properties must not be considered as definite sources from which copper ores may be extracted with profit.

(11). Apart from the Weedon and the Eustis mines, which of the mines and prospects described in this report can be considered as definite sources of copper ore? The reader is advised to turn to the detailed descriptions of the properties here mentioned that appear in later pages of this report. The Ives mine (lot 2, range IX, Bolton) is now in the stage of a promising prospect. It is of a type of deposit upon which it is advisable to do considerably more development work before too much dependence be placed upon its future. The Lake Memphremagog or Smith's mine (lot 28, range IX, Potton) is a deposit of massive pyrrhotite, the average copper content of which probably does not exceed one per cent. Dr. A. W. G. Wilson has estimated that there is 20,000 tons of this ore in sight. Because of its lower sulphur content (when pure—39.2 per cent) which can only be recovered with difficulty, pyrrhotite, as a possible source of sulphur for the making of sulphuric acid, etc., cannot compete with pyrite which when pure contains 53.3 per cent in sulphur. When in addition to this, one considers the difficulty of transporting the ore from this property and its low copper content, one cannot consider it as a major factor in the problems connected with the possible erection of a copper smelter in the Eastern Townships. If, at some time, conditions develop that would warrant the erection of such a smelter, the cupriferous pyrrhotite from this property might be used to provide the essential sulphur. Similarly, some of the large dumps of limestone at the old Acton mine, and some of the calcareous vein material on the small dump at the St. Francis mine (lot 25, range XII, Cleveland), each of which carry on the average a fraction of a per cent in copper, might be utilized as a flux for more siliceous ores. Both the Suffield and the King mines (lots 2, 3 and 4, Ascot) may be popularly considered as definite sources that would contribute regularly to a copper smelter. Concerning these properties it may be well to here repeat what is written upon a later page with reference to the Suffield mine:—The ore is of such low grade that the intention has been to erect a concentrating plant. Considering the character and quality of the mineralization, it will be a profound surprise to the writer if systematic sampling of what is now regarded as "blocked-out ore" would show the presence of an average of one per cent of copper. It is recognized that relatively small quantities of the ore may be selected that will carry several per cent. It is possible that work if carried in other directions than along the zone that is now being followed may reveal the presence of a better type of ore. Considering the property in its present state, it is incumbent that the continuity of the mineralized zone, upon which work has progressed, be more thoroughly established, and the possibility of concentrating the ore (without selecting minor portions of it) be demonstrated, before this property can be considered as a definite source that would contribute regularly to any copper smelter.

(12). Of the other properties described in this report, it seems advisable that further prospecting work should be done upon the following, in order to ascertain if they possess any value from a mining point of view. The prices at which some of the old mines are held by their owners are ridiculously high.

It is to be hoped that Mr. Pierre Tétreault, of Montreal, will prove that copper ore is yet present in commercial quantities either within or adjacent to the old workings of the Huntingdon mine (lot 8, range VIII, Bolton).

Further exploratory work may disclose the presence of a considerable quantity of low grade ore at the old Harvey Hill mine; but, at present, no work is being done.

In the hope of finding other lenticular bodies of ore, similar in character to those that have been formerly exploited on these properties, it seems advisable that further prospecting should be done at the Victoria mine (lot 4, range VIII, Ascot), at the Clark mine (lot 11, range VII, Ascot) and the Hepburn mine (lot 7, range IX, Ascot). Small bodies of low grade ore may be present at the Sherbrooke mine (lot 12, range VII, Ascot, and at the Belvidere mine (lot 10, range IX, Ascot). When one considers that the ore-bodies that were worked in the Capelton mines to a depth of about 2300 feet in the Albert shaft, were identical in their mode of occurrence, mineralogical character, and origin with those of the Eustis mine (on the adjacent property), it seems reasonable to regret that the Albert shaft had not been extended for one or two hundred feet, and, at this increased depth, further prospecting work done before the mines were abandoned. If discoveries were made upon any of the properties mentioned in this paragraph, the ore would be of a type similar to that of the Eustis mine. With the exception of the Capelton mines, these properties can be readily explored by diamond drilling at the surface.

Further prospecting work on lots 22, of ranges I. N. and I. S. of Garthby township may reveal the presence of a body of pyrite. No information seems to be available as to whether diamond drilling was done at the Moulton Hill property (lot 23, range III, Ascot) when the mine was operated; if not, there is the possibility that such drilling might encounter lenticular bodies of pyrite.

Judging from its history and the mode of occurrence of its ore-bodies, it would appear that even more risk and speculation is connected with the possibility of the finding of ore at the old Ascot mine (lot 8, range VIII, Ascot). The ore that has been extracted from this property has carried a higher average percentage of copper than any of the other properties in Ascot township.

Apart from the properties mentioned, in the writer's estimation, none of the other openings described in this report are worthy of further attention. If the price of copper again experiences a sensational rise, search might be made for small quantities of ore at the Washer's mine (lot 2, range IV, Brome) and at the Ely mine (lot 3, range VII, Ely).

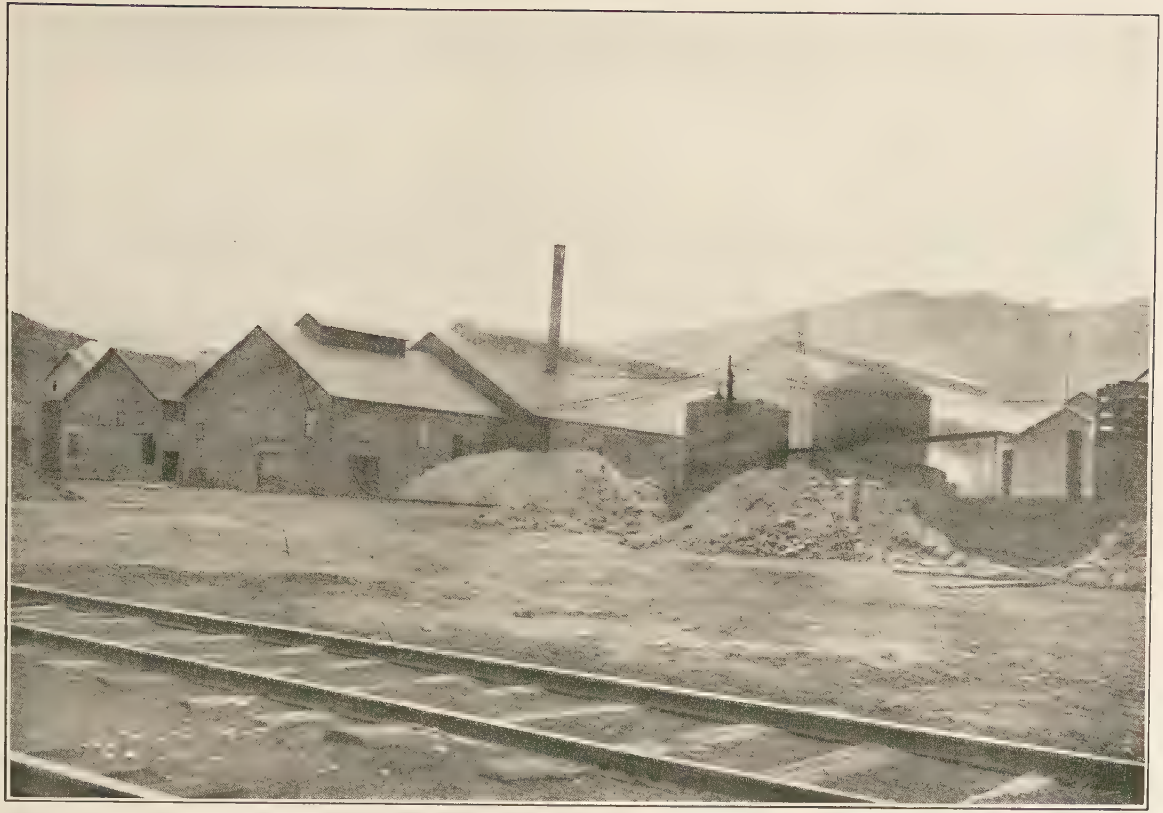
(13). As a matter of history, it should be pointed out that at different times since 1864, copper smelters have been in operation at Lennoxville, Capelton, Eustis, the Huntingdon mine, the Harvey Hill mine and at Acton. Some details concerning these plants have been given in Chapter II. of this report. It is worthy of special note that for a considerable number of years prior to 1907, the Nichols Chemical Works at Capelton intermittently operated a fifty ton Herreschoff water-jacketed furnace to treat the cinder from their acid plant. From time to time, some customs ore was treated at these Works.

(14). The type of ore most prevalent in the district is a cupriferous pyrite. The most of such ore is quite free from gangue; the ore of some properties would demand concentrating. The sulphur content of this ore may be considered as varying from 30 to 48 per cent; the ores both of the Weedon and Eustis mines carry on the average slightly more than 40 per cent in sulphur. The ore of the Weedon mine to date has averaged 3.62 per cent in copper; the average copper content of the more southwestern portion of the ore-body apparently will be somewhat lower in copper. The ore of the Eustis mine now carries an average of about two per cent in copper. *The copper ores that have been discovered in the Ascot belt, belong to this class, viz.—pyrite carrying low percentages in copper and small values in silver and gold.*

(15). Two of the properties in the Eastern Townships that have figured prominently in the literature as copper mines, in reality should have been considered as deposits of pyrite carrying negligible traces of copper. These are the Moulton Hill mine (lot 23, range III, Ascot), and the Garthby or Lac Coulombe mine (lot 22, range I. N. and I. S., Garthby). So likewise, the deposit about six miles east of the village of St. Gerard (lot 8, range VI, S. W. Stratford), from which 1600 tons of ore were shipped during the past year, is pyrite carrying a mere trace of copper.

(16). The financial success of the Weedon and especially of the Eustis and Capelton mines has depended in very large measure upon the utilization of the sulphur contents of their ores in the manufacture of sulphuric acid, etc. When by shipping to Chemical Works, they receive approximately from $3.50 to $4.50 per ton merely for the sulphur content of their ores, these mines cannot be expected to ship to a copper smelter where they would receive no payment for sulphur. If, for example, it costs $2.00 per ton to mine the ore and load it on railway cars, $2.00 per ton for freight to a Chemical Works in the United States, where the ore is treated for approximately $2.00 a ton, payment being made on sulphur and copper, it is preferable to send the ore to such a Chemical Works rather than to a Copper Smelter constructed at some point in the Eastern Townships where payment would only be made on the copper.

(17). *Apart from such deposits of cupriferous pyrite, there is not at present sufficient copper ore in sight to warrant the erection of a copper smelter. There is sufficient pyrite, the most of which is cupriferous, in sight at the present time to justify the construction of extensive Chemical Works with a copper smelter as an adjunct, provided*



The Nichols Chemical Works, Capelton, Ascot township.

that a careful study of market conditions would warrant the expenditure involved in such an undertaking.

Any group of individuals planning to organize such a Chemical Works obviously should make a thorough analysis of the trade in sulphuric acid. With the supply of cupriferous pyrite that there is in sight and the prospects of the discovery of other deposits of this ore, at first thought, it may seem surprising that the Nichols' Chemical Company at Capelton (Plate IV) does not expand its establishment. The writer does not pretend to have made a study of the demand and supply and other factors in connection with the marketing of sulphuric acid and allied products but the following statements may prove of interest. At present this acid is manufactured in Canada chiefly at the works of the Nichols' Chemical Company at Capelton, Que., at Sulphide, Ont., and at Barnet Bay, B.C., and by the Grasselli Chemical Works at Hamilton, Ont. It is also reported that some sulphuric acid is manufactured by the Victoria Chemical Co., Victoria, B.C., and by the Dominion Iron and Steel Co., of Sydney, N.S.

The following figures taken from the "Annual Report on the Mineral Production of Canada during 1913" issued by the Department of Mines, Ottawa, show that comparatively small quantities of sulphuric acid are imported into Canada. It would appear that the works now in operation very nearly meet the demand for this product in the Canadian market:—

IMPORTS OF SULPHURIC ACID.

Fiscal Year	Pounds.	Value	Fiscal Year	Pounds	Value
1885.........	774,764	$10,791	1899.......	165,637	$ 2,427
1886.........	507,927	7,930	1900.......	740,858	7,066
1887.........	678,603	8,468	1901.......	448,608	5,272
1888.........	2,494,648	35,415	1902.......	420,731	4,626
1889.........	181,652	2,606	1903.......	102,314	2,332
1890.........	211,871	2,927	1904.......	113,407	2,563
1891.........	177,627	2,466	1905.......	920,804	8,227
1892.........	222,628	2,837	1906.......	822,585	8,558
1893.........	172,422	2,367	1907.......	733,151	6,901
1894.........	107,520	1,648	1908.......	650,095	7,582
1895.........	174,605	2,481	1909.......	241,388	3,298
1896.........	114,137	1,430	1910.......	914,058	8,466
1897.........	977,446	8,033	1911.......	2,486,992	21,855
1898.........	665,344	5,536	1912.......	1,615,180	15,027
			1913.......	4,393,873	29,884

Comparatively large quantities of brimstone and native sulphur are imported into Canada as is shown by the following figures:—

IMPORTS:—BRIMSTONE* AND CRUDE SULPHUR

Fiscal Year	Pounds	Value	Fiscal Year	Pounds	Value
1880.........	1,775,489	$27,401	1897.......	8,672,751	$ 87,719
1881.........	2,118,720	36,956	1898.......	38,026,798	373,786
1882.........	2,375,821	40,329	1899.......	24,517,026	265,799
1883.........	2,336,085	36,737	1900.......	21,128,656	215,433
1884.........	2,195,735	37,463	1901.......	23,856,651	270,608
1885.........	2,248,986	35,043	1902.......	24,640,735	325,307
1886.........	2,922,043	43,651	1903.......	24,412,737	259,123
1887.........	3,103,644	38,750	1904.......	19,364,730	204,663
1888.........	2,048,812	25,318	1905.......	23,435,140	242,251
1889.........	2,427,510	34,006	1906.......	43,047,672	436,156
1890.........	4,440,799	44,276	1907 (9mos.)	25,854,615	277,439
1891.........	3,601,748	46,351	1908.......	51,806,739	517,249
1892.........	4,769,759	67,095	1909.......	44,049,172	426,569
1893.........	6,381,203	77,216	1910.......	42,943,340	430,632
1894.........	5,845,463	61,558	1911.......	50,562,547	524,473
1895.........	4,900,225	56,965	1912.......	45,039,790	465,926
1896.........	6,934,190	63,973	1913.......	72,716,339	759,585

*Brimstone, crude or in roll or flour, or sulphur in roll or flour.

A very large proportion of this sulphur is used by those engaged in the manufacture of sulphite pulp. The writer has been informed that one of the large pulp and paper companies consumes 6000 tons of sulphur annually. Some of the extensive mills in the Province of Quebec that are engaged in the manufacture of sulphite pulp should seriously consider the possibility of utilizing pyrites from the Eastern Townships in preference to sulphur from Louisiana or elsewhere. An abundant supply of pyrite, carrying from 40 to 48 per cent in sulphur, could be derived from this district. By those who have made a careful study of this phase of the subject it is pointed[1] out that with the exception of those mills that are favorably situated on the seaboard where they may directly receive the imported sulphur from vessels, the sulphite pulp mills would find it to be more economical to use pyrite, even though the initial cost of the installation of the necessary equipment would be much more expensive than that where sulphur is used. Assuming that sulphur costs $22.50 a ton, Dr. A. W. G. Wilson estimates that manufacturers could pay $6.00 a ton (of 2,000 lbs.) for pyrite carrying 45 per cent of sulphur and effect a saving of eighty cents in the cost per ton of sulphite pulp per day. Writing in the Pulp and Paper Magazine for May, 1914, Mr. G. B. Steffanson points out that:—"If the pyrites containing 45 per cent of sulphur can be delivered at the mill at a price per unit of sulphur in the pyrites amounting to about 60 per cent of the price of pure sulphur, it is generally good economy to use pyrites." From these statements it would appear that some of the Quebec mills engaged in the sulphite pulp industry would find it to their distinct advantage to use pyrites rather than sulphur, and in doing so would assist in the development of the pyrite mines and prospects of the Eastern Townships. The sulphur value of a ton of commercial sulphur equals that of two tons of pyrite carrying 45 per cent in sulphur. If its use were adopted, the tonnage of pyrite that would be demanded by pulp mills alone would be very considerable. It seems feasible that mills situated in favorable localities might use the cupriferous pyrite, and the resulting cinder then be sent to a copper smelter for treatment.

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[1] See Report on "Pyrites in Canada," by A. W. G. Wilson, Mines Branch, Ottawa, 1912, pp. 156-174.

"Uses and Market of Pyrite" by T. C. Denis, Superintendent of Mines of Quebec, Mining Operations in the Province of Quebec during 1913, pp. 46-47.

It is to be hoped that another possible solution of the utilization of the sulphur in these ores will be evolved by the development of processes that aim to recover the sulphur from sulphide ores or mattes.[1] Should any of these processes prove to be a commercial success, sulphur could be produced from these ores to replace the large quantities that are now imported.

(18). From the point of view of the copper mining industry in the Eastern Townships, that which is most desirable at the present time is a vigorous prospecting campaign. Since 1866, the industry has truly "turned in a circle." ([1]) Apart from the activity in Stratford and Weedon townships, that followed the discovery of the Weedon mine, very little new prospecting has been done in the district. A large number of the old "mines" have been repeatedly opened and closed, while the few that plainly possessed merit continued to operate. It is the belief of the writer that had the money, time and energy that have been expended upon these old "mines" (the vast majority of which are in no sense worthy of further effort) been devoted to a thorough search for new copper deposits, the names of some important copper mines would have been added to the small list of those that have been profitably operating. The country is much more accessible and can now be more thoroughly prospected than it was from 1860 to 1866. Within a very large proportion of the district, the land owners possess also the mineral rights. In some localities, large tracts of land, in part underlain by rocks favourable to the occurrence of copper minerals, are thus held by individuals or by some Company. Where the title to the land includes the mineral rights, the proprietors either should search for minerals of value, or they should be willing to grant attractive terms to encourage prospectors to enter upon their lands. If upon a proper financial basis, a Company were organized that would conduct a systematic and intelligent prospecting campaign, and at the same time would amalgamate the very few of the properties now idle that seem to be worthy of further exploratory work, it is highly probable that valuable discoveries would be made. In Canada, far too many localities may be pointed out where smelters and other works were erected before sufficient underground work had been done to demonstrate the presence of ore-bodies of requisite size and quality. No serious individuals would construct a pulp mill before having an adequate supply of wood of suitable quality in sight. The analogy speaks for itself.

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[1] "The Hall Process of Desulphurization," by H. F. Wierum, Bulletin of the Mining and Metallurgical Society of America, Sept. 30th, 1914, Vol. VII, No. 9, pp. 134-146.

For a description of the Thiogen Process—see "Pyrites in Canada," by A. W. G. Wilson, Mines Branch, Ottawa, pp. 18-21.

"The Hall Process for recovering Sulphur," by H. F. Wierum—to appear in Trans. Can. Min. Institute, Vol. XVIII.

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[1] T. C. Denis, Superintendent of Mines in Report on Mining Operations in the Province of Quebec for 1909, p. 11.

CHAPTER V.

COPPER DEPOSITS WEST OF THE SUTTON BELT.

THE ACTON MINE, RANGE III, LOT 32, ACTON.

The literature pertaining to this remarkable property is too extensive to repeat in this report. Anyone desirous of becoming familiar with the details of what has been written concerning it should read:—(i) the Geological Survey Report of Progress, 1858, pp. 56-60; (ii) "A Holiday Visit to the Acton Copper Mines," by Rev. A. F. Kemp in the Canadian Naturalist, 1860, pp. 349-362; (iii) Geology of Canada, 1863, pp. 713-717; (iv) "Contributions to the History of the Acton Copper Mine" by Thos. Macfarlane—in the Canadian Naturalist, Dec., 1862, pp. 447-471; Geological Survey Report of Progress, 1866, p. 309. A most excellent paper is that by Thos. Macfarlane.

This mine is situated about half a mile from Acton Vale station on the Grand Trunk Railway, the railway having been constructed some time before the early mining operations commenced. Copper ore was discovered on this property a few years prior to 1858 by Mr. H. P. Merrill. When Dr. T. Sterry Hunt visited the discovery in August, 1858, large blocks of limestone, heavily impregnated with bornite and evidently in place, were strewn over an area about fifty feet in length by thirty feet in width. For about seventy paces in either direction, the limestone was observed to hold little patches and seams of bornite and chalcopyrite, stained with the blue and green carbonate of copper. The limestones in the immediate vicinity were intersected by several quartz veins carrying only traces of copper. Major R. G. Leckie who joined the staff of the Acton Mine in 1861 or 1862 writes:—"I remember on the surface one immense boulder weighing thirty-five tons that averaged thirty-two per cent of copper. It stood there just like a great egg on the surface of the old limestone formation."[1]

The prospect "was purchased by Mr. W. H. A. Davies of Montreal for a very insignificant sum and royalty; but that gentleman had so little faith in his purchase that he at once let it to Mr. Louis Sleeper of Quebec on "tribute" at two-thirds of all the ore that he could obtain from it for a period of three years."[1] On September 23rd, 1858, Mr. Sleeper began to develop the mine, and in nine weeks of work, 300 tons of ore carrying about 30 per cent of copper were quarried in open-cuts without making much apparent impression on the quantity in sight. From its opening until the close of 1861, it is stated that nearly 6000 tons of ore, containing an average copper content of 17 per cent had been removed from the mine. During the thirteen months from September, 1861, when Messrs. Davies and Dunkin, the proprietors, received the mine back from the lessees, until October, 1862, when it was purchased by the Southeastern Mining Company, the total amount of ore sold was 2747 tons (of 2000 lbs.), carrying an average of 12 per cent of copper. During October, 1862, 397 tons of 15.2 per cent were produced; in November, 337 tons of 12.5; and for December, 357 tons of 13.2 per cent. Of the ore extracted in December, 1862, 88 tons averaged 22.2 per cent; 124 tons, 13.0; 35 tons, 10.6; and 110 tons 7.1 per cent of copper. Apparently operations ceased in 1864, the total production of the mine having been 16,300 tons of 12 per cent ore.

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[1] Discussion by Major Leckie, of Dr. James Douglas' paper on Early Copper Mining in Quebec. Journal of Can. Min. Institute, Vol. XIII, 1910, p. 272.

Here dolomitic limestones and shales, striking northeast to southwest, dip at very variable angles (35 degrees to 70 degrees) toward the northwest. Heavy beds of light greyish crystalline limestone, containing some irregular nodules and masses of chert form a ridge that rises to an elevation of about 100 feet above the average level. At the base of this ridge, on its western side, dark grey shales, that, according to Macfarlane, are from 20 to 80 feet in thickness, rest upon this lower limestone, and are in turn overlain by similar chert-bearing limestone, the thickness of which varies from three or four to seventy-five feet; these upper limestones lie beneath darker shales. It was here at the foot of the western slope of this ridge that this interesting deposit of copper ore occurred. Irregular dyke-like masses, up to a few yards in width, of a greenstone of the composition of a highly altered diabase, or closely allied rock, intrude the upper limestones and the underlying shales; in part, the greenstone displays an amygdaloidal structure. Macfarlane states that "this greenstone although intruded frequently between the underlying shale and the cupriferous (the upper) limestone, is sometimes observed occurring between the latter and the hanging shale."

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[1] "Copper Mining in Canada East", by Herbert Williams, M.E., Transactions of the Literary and Historical Society of Quebec, 1864-65, p. 38.

Through the action of pressure, the upper limestones and shales have by folding been locally thinned and thickened to such an extent that the limestone "occurs in the form of irregular elongated masses running parallel with the great body of limestone beneath, but variable in both thickness and texture." Complex block faulting has taken place, in which the throws usually do not exceed a few feet. Some faults trend roughly parallel to the strike of the sedimentary series with downthrows toward the northwest. In the course of the working, a fault was also encountered which had a direction of N 10 degrees W, the extent of the throw apparently not having been determined; other faults were met with striking very nearly east to west, one of which had a downthrow of 140 feet to the north. The greenstone is also traversed by the faults but it seems highly probable that some of the faulting had taken place either prior to or during the injection of this intrusive rock.

The limestones and shales of these exposures apparently form a portion of the eastern limb of a syncline, the same horizon of the western limb of which outcrops at the copper-bearing localities of Upton that have just been described. At Acton, the junction of the upper limestones and shales, with the more massive and thick beds of lower limestones, has been a line of weakness along which the intrusive greenstone has arisen, and readjustment through faulting has taken place. In a few places the lower limestones are cut by narrow stringers of quartz and calcite occasionally carrying a little chalcopyrite and galena; but the workable deposits occurred chiefly in the upper limestones and to a very minor degree in the upper portion of the underlying shales, while small portions of the greenstone also contained disseminated grains of chalcopyrite and bornite. Analyses of the limestone show that it contains considerable magnesia:—

	I.[1]	II.[2]
$CaCO_3$	71.10	73.20
$MgCO_3$	24.12	15.50
Al_2O_3 and Fe_2O_3	2.85	2.75
SiO_2	1.50	8.25
	99.57	99.70

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[1] Analysis of limestone given by Macfarlane, Canadian Naturalist 1862, p. 458.
[2] Analysis of fragment of limestone from a vein—*Ibid* p. 462.

The magnesia content is quite variable as is also shown by the statement of Dr. A. W. G. Wilson[1] of the Mines Branch, Ottawa, that it contains "approximately 87 per cent of calcium carbonate and ten per cent magnesium carbonate, with about 1.6 per cent of insoluble material, the balance being chiefly oxides of iron and alumina."

Irregular portions of this upper limestone, elongated in a direction corresponding to the strike, were brecciated; "fragments of limestone and chert, both angular and rounded, were united by a paste of variegated (bornite) and vitreous (chalcocite) sulphurets mingled with silicious matter."[2] In addition, much of the limestone adjacent to such breccia was highly impregnated with chalcopyrite and bornite. Short irregular stringers of calcite carrying chalcopyrite and bornite also intersected the limestones; occasionally these veinlets contained some black shining carbonaceous matter, identical in appearance with some forms of inspissated petroleum.

The ore taken from the property chiefly came from three large masses occurring within a length of about 720 feet. The workings are comparatively shallow. The major part of the ore was removed from large open pits or glory-holes, none of which, in the latter days of 1862, had reached depths of more than sixty-five feet, while of five shafts that then had been sunk, one had reached a maximum depth of ninety-one feet on a slope of 70° to 80°. It is stated that the productive part of the deposit was found in the limestone, and when this was passed through the smaller amounts of ore in the shale made the work unremunerative.[3]

The mine was closed down in 1864. In 1865, the late Dr. T. Sterry Hunt[4] wrote as follows:—"The ores of copper are widely disseminated in the Eastern Townships for the most part in the form of irregular beds and interstratified masses. The Acton mine was one of these, which in three years yielded ores equal to about 1000 tons of copper but is now exhausted." In the list of copper localities in the Geological Survey report of 1866 there appears the following statement:—"The masses at first in sight have become exhausted and little or no exploratory work for the discovery of others has been performed."

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[1] "The Copper Smelting Industries of Canada," Mines Branch, Ottawa, 1913.

[2] Geology of Canada, 1863, p. 714.

[3] "Report on the Copper Deposits of the Eastern Townships," by J. A. Dresser. G.S.C. Publication No. 975, p. 13.

[4] "Canada, a Geographical, Agricultural and Mineralogical Sketch." Published by authority of the Bureau of Agriculture, 1865.

Since then, several attempts have been made to locate new orebodies. In his report for 1888-89, Ells records the fact that "Several boreholes have been put down, but the results obtained have not been made available." In 1899 some exploratory work, "the results of which were reported as exceedingly satisfactory,"[1] was done at the old Acton mine by the owners of the Ascot mine. In Woodward's list of copper properties, prepared in Sherbrooke in 1902 the statement is made that "certain preparatory work has been done towards reopening the Acton mine." In 1906, "a couple of men were employed following some of the leaders of ore in the walls of the old pits in the Acton mine."[2] Writing in 1906, Obalski reports that "some prospecting was also done at the old Acton mine which it is proposed to reopen if the results are good.[3] In 1909, the water was removed from the open pits and from the shaft known as No. 5 (about 200 feet deep,) by Mr. Pierre Tétreault, of Montreal. The examination of the old workings proved to be very dissappointing. In the fall of the same year, this gentleman began the erection, at the mine, of a small copper smelter. The plant includes an Allis-Chalmers water jacketed furnace, of a capacity of eighty tons of ore a day, one Root blower of a capacity of 6,600 c.f. of air per minute, and one 80 H.P. boiler with other accessories. The plan was to treat ore from the old dumps. The furnace was blown in during the spring of 1910, but after a short run operations were suspended. About 1500 tons of ore, carrying on the average one and a half per cent in copper, were selected by hand-picking portions of the old dumps. A few hundred tons of cupriferous pyrrhotite were brought from the Lake Memphremagog mine (lot 28, range IX, Potton) to mix with the cupriferous limestone selected from the dumps. In 1913, in order to determine the possibility of the mineralization of the lower limestones, a diamond-drill hole was put down at what was considered to be the most favourable locality at the old workings but no evidences of mineralization were found. This work was done, and the dumps were sampled under the direction of Professor J. W. Bell of McGill

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[1] G.S.C., Vol. XII, 1899, p. 43S.

[2] Summary Report of G.S.C., 1906, p. 161.

[3] Mining Operations in the Province of Quebec, 1906, p. 33.

University. It is certain that none of the dumps at the Acton mine will average a half of one per cent in copper.

An examination of specimens of the ore in which bornite and chalcopyrite occur together, shows that the bornite has been developed later than and at least in very large part from the chalcopyrite. It seems probable that the mineralization of the limestone primarily originated from the action of the copper-bearing waters attending the latter stages of the cooling of the intrusive greenstone. By this means, the upper limestone, especially along and adjacent to brecciated zones, and local upper portions of the underlying shales were impregnated with scattered grains of chalcopyrite and traversed by veinlets of calcite and quartz carrying a little chalcopyrite. Later, meteoric waters produced secondary enrichment by carrying downward much of the copper values in portions of the upper limestones that have since been removed by erosion, and depositing them as bornite with some chalcocite, especially within and adjacent to the brecciated portions of the upper limestone in contact with the impervious shales beneath. If this theory be correct, it would not be expected to find a continuation at depth of rich ore, similar to that which was removed from the property in the early days. In its present condition, the Acton mine cannot be considered as a source that would contribute ore to a copper smelter. If, at some time, conditions develop that would warrant the erection of such a smelter, some of the dumps of limestone carrying a fraction of a per cent of copper might be utilized as a flux for more siliceous ores.

UPTON TOWNSHIP.

Ranges XX and XXI, Lots 49, 50 and 51, Upton. — In the report of the Geological Survey for 1847-48, where the presence of copper ores in the Eastern Townships was recorded for the first time, Sir William Logan mentions lot 51, range 21, in Upton Township, as a locality where copper ore "seems to be sufficient in amount to justify the risk of small crop trials, notwithstanding the promise of a profitable result cannot be asserted to be very encouraging." He writes:—"The lode in this instance appears to be transverse to the stratification, its course being from southeast to northwest. The rock which it intersects is the massive whitish-grey limestone, which has a breadth exceeding the distance specified.

The breadth of the lode is from a foot to eighteen inches, and it is composed of a mixture of white quartz and calc-spar in which copper pyrites is rather sparingly disseminated; the crop is much stained by thin films of green carbonate of copper. A sample of about 24½ lbs., as near to an average as could be determined by the eye, having been taken from the crop of the lode, it gave a produce of 3.84 per cent. According to this the yield of metallic copper in a fathom forward by a fathom vertical would be 300 pounds. The copper contains a trace of silver."—(G.S.C., Report of Progress, 1847-48, p. 73.)

"Quarries having been opened in the limestone of the fiftieth and fifty-first lots of the twenty-first range of Upton for the purposes of the St. Lawrence and Atlantic Railroad, the vein of a copper ore which in a previous report (1847-48) was mentioned as existing in the latter numbered lot, has become more exposed to view, and the facts furnished by a subsequent examination of the locality serve to give a better understanding of the probable mode in which the ore occurs. Several spots of ore running in a line, N.W. and S.E. nearly across the general range of the limestone, induced the supposition that the lode was transverse to the stratification, but a bed of a conglomerate character, which accompanies the fine-grained beds, having been found to make a sudden turn parallel to the course of the ore, it seems probable that in this case, as in all others in which metalliferous veins have been met with in the rocks of that part of the Province, the ore may in reality run in strata, and the irregularity be due to a twist in the stratification. The ore is very irregularly distributed in bunches, some of which might produce five, and others two to three hundredweights of between twenty and thirty per cent to a fathom of ground; but the irregularities appear too great to render the ore capable of being profitably mined, unless as an adjunct to the quarrying of the rock for the purposes of obtaining materials for building, or for burning to lime."—(G.S.C., Report of Progress, 1849-50.)

"The copper ore is in a mass of greyish-white and reddish-grey, compact, sub-crystalline, yellowish-weathering limestone, which it intersected in reticulating veins of from one quarter of an inch to an inch in thickness, always enclosed between walls of highly crystalline calcspar associated occasionally with a little quartz. These reticulating veins constituted bunches, and several of these bunches could be traced in succession in the strike of the limestone. These reticulating veins of copper pyrites did not differ essentially in their arrangement from the thin veins of quartz which vary frequently, and thin veins of titaniferous, specular and magnetic iron ores which less often have been found intersecting the magnesian limestones of this formation in various places, and I presume must be regarded as veins of segregation, filling up fissures which do not pass beyond the limits of the limestone. . . . The general dip is to the southeast, and the inclination varies from ten to twenty-seven degrees." (Sir W. E. Logan in G.S.C. Report of Progress, 1858.)

"Copper here occurs in the magnesian limestone or dolomite of the series, which in this portion of the synclinal has a thickness of from 200 to 300 feet. It is somewhat crystalline; and is divided into massive beds, which often contain chert. The upper portion of this limestone often presents a brecciated or conglomerate character; and it consists of rounded or irregular masses of limestone intermixed with irregular fragments of chert, the whole recemented. It is chiefly in this upper portion of the limestone that the copper ores most abound. The copper of Upton was first described and reported upon by the Survey in 1847 (and again in 1849) when an assay of the ore was given, and the place recommended for a crop trial. These early examinations at Upton were made on the 51st lot of the 21st range. On this, two shafts have since been sunk in the limestone to the depths of 25 and 42 feet. Good specimens of ore were obtained from these; but the working is for the present suspended. Within about one hundred feet from one of these excavations explorations have been made for copper on the 51st lot of the 20th range, in what is called the *Prince of Wales* mine. Here about 20 feet of the upper portion of the limestone band contain copper pyrites, which is most abundant in the lower part of this thickness. In some places, bunches of pure ore, eight or ten inches in thickness are met with. The bed is intersected with reticulating veins or strings, which also hold yellow copper ore, with calcspar and quartz, sometimes with small portions of the blue carbonate. Copper pyrites is also found in shales which here accompany the dolomite. The only working of this mine has hitherto been by an open cut which was carried to a depth of 40 and a width of 30 feet. According to Mr. Robb, 900 tons of rock, holding more or less copper have been excavated. This has been sorted, and a considerable quantity of ore got ready for the market, estimated in all at 40 tons, yielding twelve and a half per cent of copper. One lot of fifteen tons gave to his assay fourteen and three-quarters per cent. The value of this ore is much more than is required to pay the whole expense of mining and dressing; besides which there remains a large quantity of rock, less rich in copper, which requires machinery for stamping and washing.

The limestone band in this vicinity is sometimes associated with red slates; and it occasionally takes the form of a breccia, in which yellow copper ore appears to enter into the cement. It is traced to the northeastward for nearly a mile; when it is carried half a mile to the northwest, apparently by a dislocation. Here on the forty-ninth lot of the twentieth range, at *Bissonette's* mine, copper pyrites again appears in a bed, which seems, as before to be at the top of the limestone. The bed is about three and a half feet thick; and the ore lies in disseminated masses of various sizes, up to twenty inches long by six and nine inches thick. It may probably yield from ten to fifteen hundredweight of ten per cent ore to the fathom. Yellow copper ore has also been found in limestone on the fourteenth lot of the twentieth range of Upton."—(By Sir William Logan,—in Geology of Canada, 1863, pp. 712, 713.)

The following extracts are taken from the Appendix to the Geology of Canada, 1866, p. 308:—

"Range 20, lot 49—Yellow sulphuret disseminated in 3½ feet of a great dolomite band, yielding from ten to fifteen cwt., of 10 per cent ore per fathom. This is the *Bissonnette* mine."

"Range 20, lot 51,—Yellow sulphuret disseminated in a breadth of 20 feet of the same band of dolomite. About 40 tons of 12½ per cent ore has been obtained in open cuttings. This is the *Prince of Wales* mine."

"Range 21, lot 49—Yellow sulphuret in dolomite similar in character to Bissonnette mine. From open cuttings in the lots 49 in the two ranges, 12 tons of 20 per cent and 8 tons of 14 per cent have been obtained. Col. MacDougall is the proprietor."

"Range 21, lots 50 and 51—Yellow sulphuret in dolomite. On lot 51, two shafts have been sunk to depths of 42 and 25 feet respectively, from which much ore was obtained. On lot 50, galena is associated with the copper ore. This is the *Upton* mine."

The above information from the report of 1866 is repeated by Ells in G.S.C. Report, 1888-89, p. 33K, and also in G.S.C. Bulletin on Copper, 1904, p. 28.

Under the class of "Contact Deposits between Cambro-Silurian limestones and certain Intrusives," Dresser places the Upton deposits, and concerning them, writes:—"Upton, six miles northwest of Acton is the most remote of the deposits in that direction. Four different properties were at one time worked in this vicinity. None of the workings seem to have reached a depth of 100 feet. The ore occurs in irregular veins or stringers in the limestone which is generally crystalline. It is also finely disseminated through many parts of the limestone. A small amount of high grade ore was obtained by hand-picking. No machinery for crushing or mining seems to have been used." "(Copper Deposits of the Eastern Townships, P.Q.", G.S.C. Report, 1907.)

"Smaller mines as Upton, Wickham, St. Pierre de Durham and Roxton have produced more or less copper ore. The Upton deposit is further distinguished by the presence of a little native copper. All of these are now closed, but some of them seem likely to be worth re-opening. The little work which was formerly done in most of them was of such a character as to save only a small proportion of the ore. The gangue is almost wholly calcite, and hence useful for a flux with the dry ores of the pre-Cambrian rocks. The ores are chalcopyrite, bornite, chalcocite, and copper carbonate. They differ somewhat in the different individual deposits."—(G. A. Young in G.S.C. Report, 1902-03, p. 149AA.)

About two miles and a half to the north-north-east of Upton station on the Grand Trunk railway, a few low knolls or hummocks of limestone rise for a few feet above the otherwise flat plain. Massive beds of partially crystalline magnesian limestone strike to the northeast, dipping at angles that vary from a few degrees to about 25 degrees toward the southeast. These grey limestones, which are probably of Ordovician age, are similar in character and undoubtedly belong to the same horizon as those at the Acton mine, six to seven miles distant to the southeast. As in the limestone at Acton, irregular nodules, bunches and streaks of chert are present. A few reticulating veins and veinlets (chiefly the latter) of calcite and quartz carrying chalcopyrite, occasionally with a little pyrite and galena traverse the limestones in some localities.

Small irregular portions of the limestone, adjacent to these veinlets, have been recrystallized into coarse calcite and have been impregnated with chalcopyrite, occasionally with a little galena. Some of the best specimens of copper ore may be taken from the more cherty portions of the limestone; it would seem that the more brittle cherty streaks of very irregular outline, which, in so far as observed, attain maximum dimensions of nearly two feet in width and a few yards in length, fractured under the pressure to which these limestones were subjected, while the purer portions of the limestone chiefly absorbed the stresses by recrystallization and possibly to a slight extent by plastic flow. Examination in thin section of a fragment of cherty limestone impregnated with chalcopyrite shows that the cryptocrystalline quartz contains abundant grains of calcite and that the solutions which deposited the chalcopyrite followed minute cracks partially replacing some of the grains of calcite with chalcopyrite. Apparently, these solutions also recrystallized some of the chert, rendering portions of it less microcrystalline and even developing a few minute hexahedra of quartz. In some specimens, rounded grains of chalcopyrite, up to a half an inch across, were observed to contain a core of galena, showing that, when present, the latter mineral crystallized first. Logan* mentions "a fine-grained diorite near the copper mine at Upton," but the writer was unfortunate in not observing its presence.

From 1858 to 1864, while the Acton mine was being worked vigorously, some prospecting operations were carried on in Upton township on lots 49, 50 and 51 of ranges XX and XXI. The accompanying sketch (Fig. 1) shows the approximate position of points where this work was performed. On lot 49, range XXI (at (1) in sketch) is an open cut, 27 feet in length, about 15 feet in maximum width, and possibly 20 feet in depth. This opening has been partially filled with stones. From the old dump of fragments of limestone, a very few pieces may be found which are traversed by narrow veinlets of calcite, occasionally carrying a few small grains of copper pyrites. Three other small openings on this lot, none of which exceed eight or nine feet in depth, have disclosed nothing of value.

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*Geology of Canada, 1863, p. 604.

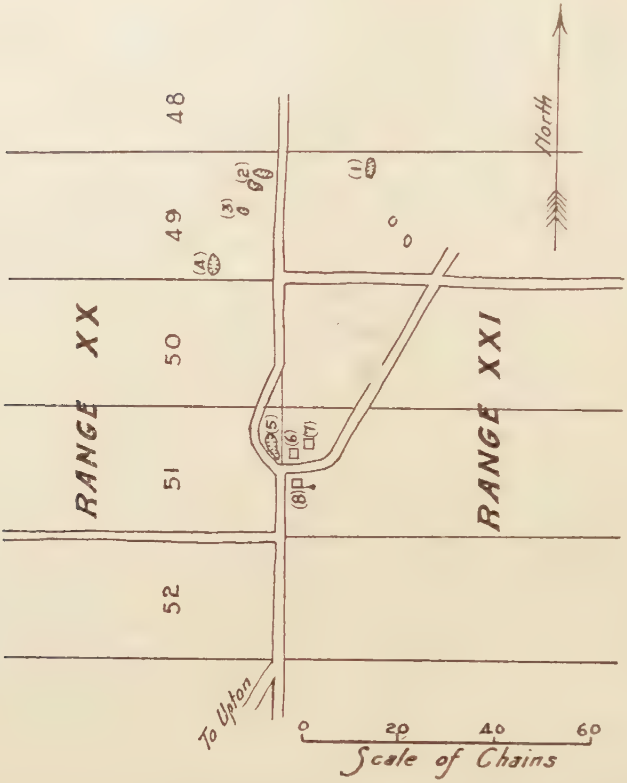

Fig. 1.—Approximate location of points, where prospecting work has been done in Upton Township.

Close to the road and just north of the home of Mr. Alphonse Frechette, two open cuts, at (2) in sketch, were made on lot 49, range XX. One of these is about 30 feet in length, 10 feet in width, and 10 feet in depth; the other is approximately 18 feet in length, 12 feet in width and 12 feet in depth. The floors of these openings are now covered with loose rocks and with overburden that has been washed into them by the rain. Nothing of economic value is visible on their walls. The dumps are essentially composed of barren limestone; a very few specimens of coarsely crystalline limestone and others of cherty limestone may be picked up that are richly impregnated with copper pyrites, occasionally associated with a few minute grains of galena. At (3) in sketch, a shallow trench was excavated across a low hummock of limestone which is 120 feet in length by about 30 feet in width. A few short reticulating veinlets of calcite and quartz carrying chalcopyrite traverse the limestone. At (4) in sketch, some shallow open cuts were made, the largest of which was about 15 feet in length, 9 feet in width and now 7 or 8 feet in depth. This was formerly known as Bissonette's mine. A few similar irregular veinlets are present at this point. It will be observed that in the Survey report of 1866, it is stated that from open cuts on lots 49 in ranges XX and XXI, 12 tons of 20 per cent and 8 tons of 14 per cent ore were obtained. In 1849, from the large opening on lot 51, range XX (at (5) in sketch), limestone blocks were removed for the building of a bridge or culvert on the St. Lawrence and Atlantic (now the Grand Trunk) railroad. Some of the limestone was also used for the burning of lime; just north of the quarry, the ruins of the old lime-kiln may yet be seen. In the southeastern portion of the wall of this quarry a small patch of somewhat brecciated cherty limestone is in part quite heavily impregnated with chalcopyrite and stained with a little azurite and malachite. Apparently, in the early days, this property was known as the Prince of Wales mine from which according to the Survey reports of 1866, 40 tons of 12½ per cent copper ore were taken.

On lot 51, range XXI, three shafts are situated. One of these, either at (6) or (8) in sketch, is of historical interest in that it is upon one of the three occurrences of copper ores in the Eastern Townships, that were first mentioned by Logan in the report of the Geological Survey for 1847-48. In that report he described this occurrence as a vein composed of a mixture of quartz and calcite, from a foot to eighteen inches in width and striking to the northwest, "within which copper pyrites is sparingly disseminated." A little galena is associated with the chalcopyrite; of its occurrence, Sir William Logan* writes:—"Irregularly distributed patches of fine-grained galena, from one to four inches in thickness, occur in the copper-bearing magnesian limestone." He also mentions that the galena "contains but little silver" and "does not appear to be in workable quantity." According to Mr. Horace Brummell, who owns the land, the shaft, at (6) in sketch, is about 60 feet in depth; at the bottom, short drifts extend toward the west and the north. The shaft is now filled with rubbish.

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*Geology of Canada, 1863, pp. 516 and 690.

At (7) in Fig. 1, a shaft which is said to have been 25 or 30 feet deep had caved in. The shaft, at (8) in Fig. 1, reached a depth of about 45 feet. A few years ago it was cleaned out, and is now used as a well to supply a near-by butter factory. A few fragments of limestone breccia, strewn in the vicinity, were taken from this shaft. Mr. Brummell informed me that in the bottom there is a vein, about four inches in width, that is rich in copper pyrites.

These irregular copper-bearing veins and veinlets at Upton are similar to those that cut the lower limestone at Acton. Concerning the localities where as yet copper ore has been found on these lots in Upton township, the words of Sir William Logan in 1849, appropriately may again be repeated:—"The ore is irregularly distributed in bunches, some of which might produce five, and others two to three hundredweights of between 20 and 30 per cent to a fathom of ground; but the irregularities appear too great to render the ore capable of being profitably mined, unless as an adjunct to the quarrying of the rock for the purposes of obtaining materials for building, or for burning to lime."

ROXTON TOWNSHIP.

What has been regarded as the most important occurrence of copper-bearing minerals at present known in this township is situated on the 23rd lot of the third range.

Range III, Lot 23, Roxton.—Farther to the southwest, on the twenty-third lot of the third range of Roxton, the limestone appears in a nearly vertical position, with shales both above and below, and having a breadth of about 100 yards. Near the summit of the band and also in contact with the overlying shale, rich specimens of variegated ore were found disseminated in the limestone and associated with calcite in irregular veins. A considerable mass of the ore has been excavated, but it is difficult to ascertain the amount of ore obtained."—(Geology of Canada, 1863, p. 718.)

"Yellow and variegated sulphuret in dolomitic limestone near diorite. The ore is said by Mr. Robb to be more or less disseminated through a breadth of 50 feet of the limestone, but it appears to be more concentrated in about one foot near the diorite. From the west half of the lot, belonging to Lord Aylmer, there had been obtained in January, 1864, 56 tons of $3\frac{1}{2}$ per cent ore, 16 tons of 5 per cent and 2 tons of 12½ per cent. From the east half, belonging to Napoleon Lafontaine, 8 tons of 8 per cent and 4 tons of 3½ per cent ore."—(G.S.C., 1866, p. 304.)

Under the name of "Lord Aylmer's mine," the above description is repeated by Ells in G.S.C., Vol. IV, 1888-89, p. 33K; and also in G.S.C. Bulletin on Copper, p. 28.

Dresser mentions that at Roxton, copper occurs "both in and near the intrusive and amygdaloidal diabase."* He classifies the occurrence with the "Contact Deposits between Cambro-Silurian Limestones and Certain Intrusives."

This lot is situated between five and six miles east of South Roxton station on that branch of the Canadian Pacific railway that passes northward through Sutton, Foster and Acton. The road from South Roxton to the property is rough and hilly. Because of the unfavorable circumstances under which my examination was made, only the workings on the western half of the lot were visited. The intrusive diabase must occur upon the eastern portion of the lot. It was from a large opening, about 30 feet long, 12 feet in width and variously estimated to be from 35 to 50 feet in maximum depth, that 56 tons of 3½ per cent, 16 tons of 3½ per cent and 2 tons of 12½ per cent copper ore were extracted in the early days when the Acton mine was being worked. Impure magnesian limestones striking N 40° E and dipping at very variable angles toward the northwest are very irregularly impregnated with grains of chalcopyrite, pyrite and occasionally a little bornite. As is shown by the dumps, the proportion of barren rock, that was handled in sorting the quantity of ore mentioned, was large. The only evidences of mineralization in the bed-rock in the vicinity of the large pit may be seen on the eastern wall where an indurated band of limestone, up to about two feet in thickness, is rusty because it is irregularly impregnated with grains of pyrite, associated with which are a very few scattered particles of chalcopyrite.

Six or seven years ago, at a point 40 to 50 yards east of the earlier workings, a shaft was sunk to a depth of 15 feet in crystalline limestone traversed by veinlets of calcite and quartz with a little chalcopyrite and bornite; portions of the limestone adjacent

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*G.S.C., Vo. XVI, 1904, p. 268A; and in Report on the Copper Deposits of the Eastern Townships, G.S.C. Publication No. 975, 1907, p. 13.

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to these veinlets are irregularly impregnated with chalcopyrite and bornite. A few good specimens of copper ore may be here collected.

Although further prospecting in the vicinity may lead to the discovery of workable deposits, it seems plain that at these points where work has been performed, the copper bearing minerals have been found to be too irregularly and sparsely distributed to yield profitable returns.

Durham Township.

Of the occurrences of copper-bearing minerals known in this township, that on lot 21, range VII, figures prominently in literature.

The Durham (or Yale's) Mine—Range VII, Lot 21, Durham.—"At this mine, several veins, carrying more or less copper, intersect a mass of magnesian limestone, which is supposed to belong to the same band as that of the Acton mine. The veins have a general bearing north-eastward, and trial shafts have been sunk on three of them, the thicknesses of which vary from 6 to 30 inches. The vein stone is calcite with a little quartz, occasionally mixed with portions of the wall-rock. On the most northwestern vein, the excavation is two fathoms deep, and reaches black shale beneath the limestone. On the middle one which is 18 feet to the south-east, the excavation is six fathoms deep, again reaching black shale; and on the third, 24 feet farther to the southeastward, a shaft sunk about four fathoms is still in magnesian limestone. In this shaft, the vein has an underlie to the southeastward of about a foot in a fathom, and in a breadth of from six to twelve inches, shows good lumps of ore, mixed with calcite and wall rock."—(Catalogue of Economic Minerals of Canada, London International Exhibition, 1862, p. 13; also in Geology of Canada, 1863, p. 718.)

"Yellow sulphuret in veins of calcite cutting dolomitic limestone. Trial shafts have been sunk in three veins, varying from 3 to 12 inches, and at various depths through the limestone, the greatest 84 feet, have terminated in black slate, losing the copper ore. From all the shafts and galleries the ore obtained is estimated at 10 tons of 5 per cent, 110 tons of 3 per cent and 300 tons of 1 per cent. This is the Durham mine."—(G.S.C., 1866, p. 310.)

"In the township of Durham, adjoining Acton, the same character of ore is found (as at the Acton mine). Two mines were here started, of which that on the 21st lot of the 7th range, styled the Durham mine, was apparently the more important. Shafts were here sunk on three veins, varying from 3 to 12 inches in width, the deepest of which was eighty-four feet, ending in black slate. The ore obtained amounted to 10 tons of 5 per cent; 110 tons of 3 per cent, and 300 tons of one per cent, consisting of yellow sulphuret in a calcite vein cutting dolomite."—(R. W. Ells in G.S.C., Vol. IV, 1888-89, p. 36K; also in G.S.C. Bulletin on Copper, p. 31.)

This property is situated about 12 miles north of east from the Acton mine, and 4 to 5 miles north of South Durham station on the Grand Trunk railway. It was not visited by the writer, but is included in this report because it is frequently referred to in the literature. In his reports, Ells repeats the statement concerning the production of this property, but he does not make it very plain, as is stated in the Geological Survey Report for 1866, and later by Dresser, that the ore-supply failed when the excavations reached the underlying shales.

CHAPTER VI.

COPPER DEPOSITS OF THE SUTTON BELT.

SUTTON TOWNSHIP.

During 1862 to 1864, some shipments of "ore" were made from the property known as Sweet's mine on lot 8, range X of this township. Two tons of ore, carrying five per cent copper are reported to have been taken from lot 11, range X.

Sweet's Mine, Range X, Lot 8, Sutton.—"The iron slates of this region often contain a little disseminated copper pyrites, or are stained with the green carbonate, which also sometimes occurs in the dolomites associated with these specular schists. On the eighth lot of the tenth range of Sutton, on the eastern side of the synclinal, copper ore is found in larger quantity, and mining operations have been commenced in a band of fine micaceous or nacreous slates, which run in a northward direction and dip at a high angle to the westward, or are nearly vertical. These strata are exposed for 500 feet and may be traced for half a mile along the strike. . . . The copper ores "consisting of the yellow, variegated, and vitreous sulphurets, are disseminated in grains or small thin lenticular masses. The proportion in which the ores occur is variable. The bed in which the principal excavations have been made is said to vary from six inches to nearly three feet; and about eight feet to the east of this another cupriferous bed, of six inches in width, has been observed. The copper may, however, be disseminated through a greater breadth than these measures indicate. In one excavation made here, the ore appeared to be more or less diffused through a breadth of four and a half feet; and the assay of a sample from this cutting gave four and a half per cent of copper as the average from this thickness of rock. A layer of fine-grained blackish slate, an inch in thickness from this place, which seemed to owe a portion of its colour to vitreous ore, so finely divided as to be scarcely apparent to the eye, yielded on assay ten per cent of copper. A shaft of ten fathoms has been sunk on the incline of the bed, and a small quantity of ore extracted. Small quartz veins, holding variegated copper ore, are met with cutting these cupriferous slates."—(Geology of Canada, 1863, p. 721.)

"Variegated and vitreous sulphurets in a bed of nacreous slate of from 1 to 4½ feet in width. This is generally known as Sweet's mine. Since 1862 a short cross cut has been driven from this bed, at the depth of 60 fathoms, intersecting another bed holding yellow sulphuret. On this, another shaft has been sunk, and a considerable quantity of good ore has been raised to the surface."—(Geol. Surv. of Can., 1866, p. 296.)

"Sweet's mine, where variegated and vitreous sulphurets occur in a bed of nacreous schists from 1 to 4½ feet wide which for the whole breadth, yielded 4½ per cent of copper. A band of dolomite occurs in the vicinity, but the ore is confined principally to the schists; differing in this respect from those of the first belt of which the Acton mine may be taken as the type. This mine was one of the first opened in this portion of Quebec. . . . A considerable quantity of ore was raised from the Sweet mine, but probably the limited size of the lode interfered with its successful development." —(R. W. Ells in Geol. Surv. of Canada 1888-89, pp. 37-38K; also in Geol. Bull. on Copper, No. 882, 1904, pp. 32-33.)

"The ore occurs in nacreous slates in which it is disseminated in thin lenticular patches and in grains, as in Harvey's Hill mine. The thickness varies from 1 to about 4½ feet, and the bed dips N. 77° W<86°-90°. In this attitude it is visible for 170 yards and is traceable for a mile running parallel with a band of dolomite, which is removed from it about a half a mile across the strike and to the eastward. Nodules of magnesian limestone are disseminated in the slate close along the eastern side of the part charged with copper ore. The band of dolomite is supposed to be in the same stratigraphical place as that of Acton, but it occurs on the eastward side of a distinct synclinal form, the axis of which is separated from that to which the Acton band belongs, by about twelve or fifteen miles. A sample of the whole breadth of the bed, where it is four and a half feet wide yielded four and a half per cent. A pit of ten fathoms deep was, last year, sunk down the incline of the bed and a small quantity of the ore stoped out at the bottom."—(G.S.C. Descriptive Catalogue of the Economic Minerals of Canada sent to the London International Exhibition for 1862, p. 15.)

The excavations that are known as Sweet's mine are situated 200 to 300 yards south of the road that, passing from Sutton to North Sutton, Post Office, crosses obliquely the northern end of lot 8, range X. Here chlorite schists strike N. 30° E. and are vertical, or dip steeply to the northwest. In the field, a portion of the chlorite schists, especially those to the west of the main opening, were considered as the highly metamorphosed equivalent of fine-grained porphyrites or some allied rock. Some of the schists, however, are altered sediments; one band, less rich in chlorite than the others is an altered sandstone containing abundant rounded grains of quartz, magnetite, leucoxene, rutile and zircon. Either contemporaneously with or after the development of schistosity, irregular grains of tourmaline developed in this rock; subsequent pressure fractured some of the tourmaline grains and pulled apart the resulting fragments.

Along a few parallel bands or zones, where the schistosity is more intense than usual, the schists appear rusty. In general, the rusty appearance is caused by the presence of particles of pyrite or small octahedra of magnetite, but in places a little chalcopyrite, bornite and chalcocite are also present. These mineralized zones of shearing are usually narrow and a few feet or yards in length. One of them attained a maximum width of about five feet in the vicinity of the main opening on the property. Following one of these bands along the strike, it pinches, swells or forks, and upon dying out, may or may not be continued after a prolonged break where no mineralization has taken place.

Along a few of the planes of schistosity, the sulphides are locally quite abundant, but in general they are very sparsely distributed. A few veins of quartz and iron-bearing carbonate (probably ankerite), up to eight inches in width and a few feet or yards in length, trend parallel to the schistosity. These veins carry very widely scattered particles of these sulphides. When working the property, portions of some of these small veins yielded good specimens of copper ore.

The main opening on the property is about 35 feet in length, seven or eight feet in width and sunk to a maximum depth of about 150 feet. It followed the widest portion of the most important of these sparsely mineralized zones. At the bottom, drifts were extended for about 30 feet in either direction, and some short crosscuts are said to have been driven. Two other shafts, each probably 20 to 30 feet deep were sunk and a few other shallow openings were made on the property.

No mining work has been done since 1862 to 1864 when it was found that with depth, the irregularly distributed copper values declined to almost nothing, while disseminated pyrite remained. An elderly gentleman, Mr. Ogden Sweet, upon whose property the mine is situated, informed me that considerable ore was then taken by team to the railway at Farnham, about 20 miles distant. "Some of the ore was high grade, but too much dead rock was mixed with it."

Considering the mode of occurrence of the deposit, it was no surprise to learn that "what ore was shipped away did not pay the freight." It would appear that primarily the schists were impregnated with pyrite and a very small amount of chalcopyrite; that through processes of secondary enrichment, the copper values became somewhat concentrated at the surface, as shown by the development of a little bornite and chalcocite. Although irregularly distributed, these minerals were present in sufficient amount to attract attention when copper was selling at very abnormal prices. Penetrating below the zone of secondary enrichment, copper values declined to practically nothing and the work ceased.

Range X, Lot 8, N¼, Sutton.—On the same lot and very nearly or quite in strike with the main opening of Sweet's mine, and north of the road, on the property of Mr. E. E. Farmer, four years ago a shaft was sunk to a depth of 18 or 20 feet. The schists are similar in character to those of the Sweet's property and are traversed by similar veins of quartz and ankerite. In a zone about 18 inches in width the chlorite schists are irregularly impregnated with grains and crystals of pyrite and a very few grains of copper pyrites and bornite. Toward the northeast corner of the same lot an opening, 3 feet in depth, has been made in a similar rusty band of schists at a point where it attains a width of about four feet. Here, sparsely disseminated particles of pyrite and pyrrhotite are present, but no trace of copper was observed.

Range X, Lot 10, N.W.¼, Sutton.—"Yellow sulphuret in small quantity in a thick bed of iron pyrites."—(G.S.C., 1866, p. 296.)

Although not mentioned by Ells in his reports, a symbol upon his map indicates the presence of copper upon this lot.

Here, three small openings have been made, the deepest of which, although now partially filled up, did not probably exceed four feet in depth. Narrow rusty bands of chlorite schist containing a small quantity of pyrite, in the form of finely disseminated particles, possess no possible economic value. No trace of copper was observed.

North Sutton Mining Co.—Range X, Lot 11, N.W.¼ Sutton.—"Yellow sulphuret in a bed of from 8 inches to 2 feet wide, in talcose slate, at its junction with black plumbaginous slate. Three trial shafts have been sunk on the course of the bed, one of them to a depth of twelve feet, and about 2 tons of five per cent ore obtained."—(G.S.C., 1866, p. 296.)

This information repeated by Ells in G.S.C., 1888-89, p. 38k; also in G.S.C. Bulletin on Copper, No. 882, p. 33.

These remarks apply to the relatively small portion of the northwestern quarter of this lot that lies west of the road leading north to Brome. A shaft has been sunk to a depth of twelve feet in chlorite and sericite schists, striking N. 28° E. and dipping 85° to the west. For a width of about 18 inches in the shaft the schists are very rusty due to the oxidation of disseminated particles of pyrite with an occasional grain of copper pyrites and bornite.

A few narrow veins of quartz and ankerite that pinch and swell to a maximum width of four or five inches contain particles of these metallic minerals so scattered that although a few good specimens may be found, the most of the vein material is barren.

Southward from this shaft three other small openings occur, one of which is about four feet in depth. Similar irregular quartz veinlets and narrow rusty bands of the schist containing a few scattered grains of pyrite and occasionally a speck of copper pyrites explain why these holes were made. The irregular character of the veins that traverse these schists is well exemplified near one of these small openings, where a barren quartz vein, a few feet in length, swells to a maximum width of about three feet. None of the rock exposures examined upon this lot would suggest the advisability of further work being done.

Range XI, Lot 7, S. E.¼, Sutton.—"Yellow sulphuret disseminated in grains and interposed in thin plates between the laminae of soft chloritic slates through a width of 4 feet. According to Mr. Robb, a gallery driven 50 or 60 feet in the course of the bed has yielded a considerable quantity of ore." (G.S.C. 1866, p. 297.)

"In the southeast half of lot seven, range eleven, explorations on a four feet band in chloritic slates yielded according to Mr. Chas. Robb a considerable quantity of ore." (R. W. Ells in G.S.C. 1888-89, p. 38k; also in G.S.C. Bulletin on Copper 1904, p. 38k.)

Here chloritic schists, striking approximately N. 35° E. and dipping very steeply to the west are traversed by a few irregular veins of quartz and ankerite, each vein extending for a few feet or yards parallel to the schistosity and then tapering to a point. Never exceeding four or five inches in width, these veins, as well as a few irregular rusty bands of the schist, up to a few inches in width, contain widely disseminated particles of copper and iron pyrites. In general, these rusty bands are poorly mineralized and in any width of the schists that may be selected, they comprise but a small percentage of the whole. A trench forty-five feet in length has been driven S. 35° W., and although probably it has been filled in to some extent, it now possesses a maximum depth of eight feet. This occurrence is not of economic value.

Range XI, Lot 10, S. ½, Sutton.—"Yellow sulphuret associated with iron pyrites." (G.S.C., 1866, p. 297.)

A shaft, now partially filled up, but formerly possessing a depth of ten or twelve feet, has been sunk in chlorite schists, striking approximately N. 35° E. and vertical in dip. These schists are traversed by a few irregular veinlets of quartz and siderite which in common with rusty bands of the schist, a few inches in width contain disseminated particles of iron pyrites. No trace of copper was observed.

Range XI, Lot 11, E. ½, Sutton.—"Yellow sulphuret in spots in white quartz cutting chloritic slate."—(G.S.C. 1866, p. 297.)

Although not mentioned in the reports by Ells, a symbol upon his map indicates the presence of copper ores upon this lot.

On the southeastern quarter of this lot, a shaft was sunk in chlorite schists to a depth, it is said, of 20 or 25 feet. The schists are traversed by a few irregular quartz veins, one of which, judging from fragments on the dump, must have attained a maximum width of about a foot. A few small crystals and grains of pyrite are disseminated within these veins, and also in rusty bands of the schist, these bands never exceeding a few inches in width. The shaft is now full of rubbish.

On the northeastern quarter of this lot, at a point which is about sixty yards east of the road leading north to Brome, fissile sericite schists, striking N. 42° E. and dipping 85° to the west, are rusty in streaks because of the presence of fine disseminated grains of pyrite and pyrrhotite. Two openings have here been made; one possesses a depth of four feet, while the other is a cut, about six feet into the eastern face of a steep exposure. Within the latter a few minute particles of copper pyrites may also be found. None of the rock exposures examined upon this lot would suggest the advisability of further work being done.

North Sutton Mining, Range XI, Lot 12, W. ½, Sutton.—"Yellow sulphuret in small quantity associated with much iron pyrites, and accompanied by calcspar, manganese and dolomite. The vein or bed is seven feet wide and occurs in nacreous slate. Two shafts, 100 yards apart, have been sunk on the vein to depths of 14 and 19 feet respectively." (G.S.C. 1866, p. 297.)

"Explorations were also carried on by this company on a seven foot vein in nacreous slates, on the west half of lot 12, range XI, carrying yellow sulphuret with iron pyrites, but no returns are at hand from this exploration. Two shafts of a depth of 14 and 19 feet respectively were sunk." (G.S.C. 1888-89, p. 38k; also in G.S.C. Bulletin on Copper, 1904, p. 33.)

Upon the south-eastern quarter of this lot, one prospect shaft was sunk to "a depth of not more than twenty feet", in chlorite schists. These schists striking N. 33° E. with nearly vertical dip, are traversed by a few veinlets of quartz, one of which, an inch in width was observed to contain crystals of pyrite up to a half an inch across. Rusty bands of the schist, never exceeding a few inches in width, contain small particles of pyrite. No trace of copper-bearing minerals was observed by the writer; but Mrs. Safford who now lives upon this property and who remembers when this work was done informed me that they found a few specimens of copper pyrites. The shaft has been filled with rubbish. As a mining prospect, the property is of no value.

Brome Township.

Washer's Mine.—Range IV, Lot 2, Brome.—Yellow sulphuret in micaceous and chloritic slate. (Geol. Surv. of Can., 1866, p. 298.)

A specimen of "copper pyrites in grey talcoid slate from a bed" on this property was displayed at the Philadelphia International Exhibition, 1876. In the Descriptive Catalogue (p. 28) accompanying the collection of the Economic Minerals of Canada on that occasion, the statement appears:—"The cupriferous bed from which this specimen is taken is said to be from fifteen to twenty feet thick. The course of the bed conforms with the prevailing N. E. and S. W. strike of the rocks of the region."

Although comparatively little is said in literature concerning this property it is claimed by those that know its history, that in the early days a better grade of ore was extracted than from any of the other occurrences of copper minerals in Brome and Sutton townships. It is said that no work has been done on the property for forty years or more.

Situated upon the summit of a ridge composed of chlorite schists striking N. 42° E. with vertical dip, the geological conditions are identical with those of "Sweet's mine" on lot 8, range X, Sutton. Along parallel bands or zones where the schistosity is best developed, the schists are rusty upon weathered surfaces because of the presence of disseminated pyrite, chalcopyrite and a little bornite. Along some of the planes of schistosity, the sulphides of copper are locally quite abundant, but, in general, they are sparsely distributed. A few narrow veins of quartz and iron-bearing carbonate (probably ankerite) with a maximum width of eight inches, and a few feet or yards in length trend parallel to the schistosity. These veins contain some chalcopyrite and bornite; when the property was worked, they contributed some excellent specimens of copper ore.

Where the main opening (1) in Fig. 2 is situated, one of the rusty bands attained a maximum width of about nine feet. Northeast of this opening, which is said to be slightly more than 100 feet in depth, the rusty band separates into narrow irregular rusty streaks dovetailed into barren schist. Opening (2) in Fig. 2 is situated upon a narrow parallel mineralized zone. At (3) in Fig. 2, a shaft, 9 x 14, is said to have a depth of about 50 feet; within this shaft the sulphides were more widely scattered than in the other openings.

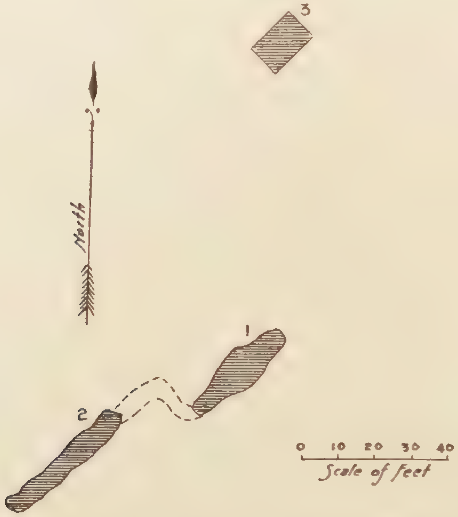

Fig. 2.—Surface plan showing the relative positions of the openings at Washer's mine.

When the property was worked, a concentrating mill was operated upon an adjacent lot near where the railway now passes. No data were obtained concerning the amount of ore treated. Undoubtedly, the copper values within these mineralized shear zones proved to be too irregularly distributed to constitute a profitable mining enterprise.

Canada Copper Mining Company (known also as the Shepherd Mine.) Range V, Lot 5, E. ½ Brome. "In the strike of Sweet's mine (range X, lot 8, Sutton) and in the same kind of slates, yellow, variegated, and vitreous sulphurets of copper occur on the fifth lot of the fifth range of Brome. Several shafts have been sunk on the deposit by the Canadian Mining Company to depths varying from 60 to 90 feet. The thickness characterized by the ores varies from 2 to 13 feet, but in addition to an increase of thickness, there may be some undulation or repetition to account for the latter dimension. The dip of the strata appears to be pretty regular, being N. 47° to 52° W.$<$70° to 90°. The working of this mine has been discontinued within the last six months, and I am not aware what quantity of ore was raised from it, nor what may be the average yield in metallic copper of the deposit as it lies in place; but if I may judge from 30 or 40 tons lying at the surface it probably would not exceed two or three per cent." (Jas. Richardson in G.S.C. 1866, pp. 37-38.)

"Yellow and variegated sulphurets in nacreous slate in 3 bands varying from 2 to 13 feet thick, supposed to be repetitions of one bed by undulations. Three shafts have been sunk to a considerable depth, and much ore obtained, the bands upon an average yielding about 3 per cent. Machinery for crushing and dressing the ore has been erected on the adjoining lot (No. 4) where there is a good water power, but the mine is at present not in operation." (G.S.C., 1866, p. 298.)

Exactly the same information as above is repeated by Ells in G.S.C. Report for 1888-89, p. 38k and in the G.S.C. Bulletin on Copper, 1904, p. 33.

"On lot 4,* Range V, within three quarters of a mile of the C.P.Ry. Work done shows yellow and vitreous sulphurets. Machinery for crushing erected, operated by good water power. Also E. ½ lot 4, Range V, yellow and purple ore, 3 bands in slate formation 2 to 13 feet wide. Considerable development work done." (Partial List of Copper and Sulphur Properties in the Eastern Townships, published by J. R. Woodward in Sherbrooke, 1902.)

In 1863-64 extensive "mining" operations were carried on in the northeastern quarter of this lot, which is situated about two miles from Brome village. Chlorite schists, striking N. 45° to 50° E. and either vertical or dipping very steeply to the southwest, represent the metamorphic equivalents of fine-grained porphyrites, probably of intrusive origin. On the surface, three or four parallel bands of these schists are rusty in appearance because of the presence of disseminated particles of pyrite, sometimes with grains of chalcopyrite and a few of bornite. Occasionally the sulphides are present as films or minute veinlets intercalated in the schist. Within the rusty bands, a few narrow irregular stringers, composed of quartz and calcite carrying widely scattered grains of the sulphides mentioned, trend parallel to the schistosity. In following any of the four or more rusty bands that occur in the vicinity of where prospecting operations were conducted, they prove to be very variable in width; at one point they may be a few feet in width, but in a few feet or yards along the strike they pinch to a few inches, become braided or forked into separated narrow rusty bands, or taper to a point. Within these bands, the sulphides are very irregularly distributed; at no point do they constitute more than one to two per cent of the width of a mineralized band, and usually pyrite is the only sulphide present.

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*Through error, lot 4 is here mentioned instead of lot 5. In so far as could be learned, no prospecting work was done on lot 4,—and on lot 5, only upon the eastern half of the lot.

The writer is in possession of a pamphlet, prepared in January and February, 1864, including reports on this property by the Directors of the Company, by Professor George I. Chace of Brown University, and by Thos. Petherick, M.E. These are instructive in that they display the views and conditions of that time. As was then universally believed, they looked upon these mineralized shear zones or rusty bands as copper-bearing beds, and, attributing to them the customary regularity of beds, believed they could follow them by tunnels for long distances. With most superfluous optimism the report announces—"we believe the ores of the Canada mine will average 2½ per cent of copper." Planning to concentrate the ore from 2½ to 20 per cent, they estimated that from the property, 300 miners would produce, in one month, 6,000 tons of 2½ per cent, which would be the equivalent of 750 tons of 20 per cent valued at $90,000. Taking the total expense per ton as $5, they deducted $30,000, thus estimating a profit of $60,000 per month or $720,000 per year, "or 146 per cent annually on the par value of the stock." At that time, $1.25 a day was the maximum wage for a miner. In New York, during the years 1863 to 1865, the value of copper fluctuated from 29 to 55 cents a pound; in the months of January and February, 1864, from 39 to 42 cents a pound. The property is

15 miles from Waterloo, at that time the nearest railway station being the terminus of the then Stanstead, Shefford and Chambly railroad.

At the time the above report was prepared, three shafts had been sunk on the property, each of which was supposed to have penetrated a separate copper-bearing bed. Shaft No. 1 reached a depth of 67 feet; at 61 feet drifts were extended to the northeast and southwest for 17 ft. and 31 ft., respectively. The "vein" or "bed" is referred to as having been 6 ft. in width with 2 to 2½ ft. of this width very rich in iron pyrites, and the statement is made in the report that "the pyrite may be confidently expected to give way to the sulphuret of copper."

Shaft No. 2 reached a depth of 75 feet. Part way down this shaft, a cross-cut was driven through barren schist for about 30 feet toward the west; drifts were started at a depth of 67 feet. Within this shaft, the "vein" or "bed" is described as from three to four feet in width, and as having penetrated "the most valuable of all the beds.'' It is stated that "more than one-fourth part of slate taken out of the shaft has been laid aside as ore".

Shaft No. 3 is described as having reached thirty to forty feet in depth. "The rocks are here charged with iron pyrites for a breadth of 12 feet. About one-ninth part of the rock raised in sinking the shaft was saved for ore."

During a few months after the writing of the above report, a mill was erected upon the adjoining lot for the concentrating of the ores. Very little further mining work was done on the property. It is said that shaft No. 2 was deepened for several feet and the drifts extended, but it was found that with depth the small percentage of copper present in the upper workings became even lower.

Upon examining the geological conditions, as displayed on the surface, it was not surprising to learn that, although with copper at a very high price and labour very cheap, operations were suspended within a year after the appearance of the above glowing report. According to an elderly gentleman, by the name of Dellaire, who worked in this mine, the men engaged in the mining work did not receive their pay for the two months prior to the closing down of operations. Only the former site of the mill may now be pointed out. It is said that no ore was shipped from the property.

The Bedford Mining Company.—Range VI, Lot 6, Brome.—"Variegated sulphuret in dolomite and yellow sulphuret in slate; considerable exploratory work has been done, but the result is uncertain." (G.S.C. 1866, p. 298.)

"The same deposit (same as that of the Canada Copper Mining Co., range V, lot 5) continues on the sixth lot of the sixth range of the township and two shafts were here sunk on it by the Bedford Mining Company, one of them 50 and the other 90 feet deep, but the work in them has been for the present suspended. It is probable that the yield of the deposit on this lot would be much the same as that of the previous one (range V, lot 5)." (James Richardson in G.S.C., 1866, p. 38.)

" On lot 6, range VI, considerable exploratory work was carried on by the Bedford Mining Co., but with no satisfactory result." (R. W. Ells in G.S.C. 1888-89, p. 38k; also in G.S.C. Bulletin on Copper, No. 882, p. 33.)

Two shafts, reported to be 50 and 90 feet deep, were sunk near the southwestern corner of this lot upon the northeasterly continuation of the same schists as those within which the Canada Copper Co. carried on prospecting operations near the northeastern corner of lot 5, range V. In fact the deeper of the shafts was believed to be on "the same bed" as that in shaft No. 2 of the Canada Copper Co. The other shaft, formerly known as Freeman's shaft, encountered a narrow vein of quartz and calcite carrying scattered particles of bornite. The property is of no value as a mining prospect.

Range VII., Lot 6, Brome.—"Variegated sulphuret in nacreous slate occurs in two parts of the lot. The thickness characterized by the ore in one of these is between 2 and 3 feet, and the yield in copper may be about 1 per cent; while in the other the thickness is about 5 feet, and the copper about 1½ per cent." (G.S.C., 1866, p. 298.)

This information is repeated by Ells in G.S.C., 1888-89, p. 38 K, and also in G.S.C. Bulletin on Copper, 1904, p. 34.

Although couched in terms that are not very attractive, it was impossible to find anything upon this lot that would in any sense correspond to the above description. This lot is very flat, being almost completely underlain by rich alluvium.

Tibbet's Hill Mine, Range VIII, Lot 12, W. ½, Brome.—Concerning range VII, lot 12, W. ½, it is stated in G.S.C., 1866, p. 298, that:—

"Yellow sulphuret characterizing a band at the junction of nacreous and chloritic slate. A shaft has been sunk on the deposit to the depth of 18 feet. This forms Tibbet's Hill Mine, owned by Messrs. Ball and Morrell."

Ells repeats this information in G.S.C., 1888-89, p. 38 K, and again in G.S.C. Bulletin on Copper, 1904, p. 33.

This is an instance where possibly by a misprint at first, the error has been later twice repeated that this shaft is on the western half of lot 12, range VII., whereas no shaft exists there. The western end of lot 12, range VIII., is situated on Tibbet's Hill and here a shaft was sunk upon a narrow band of chlorite and sericite schists containing a few disseminated grains of pyrite. The shaft is now filled up with rocks.

Range VIII, Lot 13, Brome.—"Yellow sulphuret in small quantities in soft green chlorite slates with quartz." (G.S.C., 1866, p. 298.)

On the south-east quarter of this lot, on the eastern slope of a low hill, a prospect shaft has been sunk to a depth of nine or ten feet in chlorite schists, striking N. 40° E. and dipping 85° toward the northwest. Veinlets of quartz with a yellowish carbonate, and never exceeding three inches in width, are enclosed within the schists. These small irregular veins contain a few grains and crystals, up to one half inch across, of iron pyrites. About one hundred and fifty yards to the southwest of this opening a trench, eighteen feet long with a maximum width of two feet, has been dug transverse to the schistosity. Here the schists also are traversed by similar veins that push and swell, one of them locally having a width of about a foot. Within these veins a few small grains of pyrite may be found. The writer was informed that a few specimens showing the presence of a little copper pyrites had been taken from the shaft, but it is very plain that the prospect is of no value.

Range VIII., Lots 18 and 19, and Range IX., Lot 21, Brome.—On range VIII, lot 18.—"Variegated and vitreous sulphurets occurring in 4 bands in nacreous, chloritic and epidotic slate and dolomite in the breadth of several yards. An excavation to the depth of 12 feet has been made through soil and clay to the rock, but no sufficient work to test the deposits has been made. A continuation of the same deposits extends to lot 19." On range IX, lot 21.—"Variegated, vitreous and yellow sulphurets in slates and dolomite, being a continuation of the ores of lots 18 and 19, range VIII." (G.S.C., 1866, p. 299.)

This information is repeated by Ells in G.S.C., 1888-89, pp. 38-39 K, also in G.S.C. Bulletin on Copper, 1904, p. 34.

In the prospectus entitled "Partial List of Copper and Sulphur Properties in the Eastern Townships," by J. R. Woodward of Sherbrooke, published in 1902, the amazing statement is made:—"Brome, lots 18, 19 and 21, range VIII, variegated and vitreous sulphurets, shaft sunk 175 feet. Rich ore. 1¼ miles from C.P.Ry."

On lot 18, range VIII, a small opening, representing the result of one or two blasts, has exposed barren chlorite schists. On lot 19, range VIII, no work has been done. On lot 21, range IX, two small openings were made, one of which was two feet and the other four feet in depth. Both of these holes have been filled up and are now covered with grass. A few yards removed from the deeper opening, an exposure of chlorite schists is traversed by veinlets of quartz and siderite, scattered through which, as well as through the enclosing schists, are a few isolated grains of pyrite. The positions of these small excavations on lot 21 were pointed out by the owner, Mr. Marshall Shepard, seventy-four years of age, who had worked in several of the copper mines of the Eastern Townships, and who assured me that no copper minerals had been found on either lots 18 and 19, range VIII, or on lot 21, range IX.

Range IX, Lot 25, E. ¼, Brome.—Locally known as Eastman's mine, on the bank of a brook that traverses this lot, a trench has been dug which is about 40 feet in length. As the work proceeded, the trench was filled up with the exception of the southern end, now 10 feet deep. Rusty mica schists are traversed, parallel to their schistosity, by a vein striking approximately N. 35° E. and dipping 60° toward the northwest, which is composed chiefly of calcite and quartz. Judging from loose fragments, the vein, at some point, must have attained a width of 13 or 14 inches. A few scattered grains of pyrite and two or three particles of galena were observed within the loose vein material. Indications do not justify further prospecting operations at this point.

SHEFFORD TOWNSHIP.

Range 11, Lot 26, Shefford.—A shaft was sunk to a depth of 18 feet in chlorite schists traversed, parallel to their schistosity, by a few irregular veins of quartz, containing some ankerite, a little chlorite and a few scattered grains of pyrite. From an examination of loose material it was observed that one of these veins in the shaft attained a maximum width of slightly more than a foot. These veins are only a few yards in length and are very irregular in width. The owner of the property who remembered well the days when the prospecting work was being done, informed me that at the bottom of the shaft one of these veins quite suddenly widened to about three feet and contained a few specks of chalcopyrite as well as grains of pyrite. The shaft has been filled with stones. As a mining prospect the property is of no value.

The Glencoe Mining Company, Range 11, Lot 27, Shefford.—"Yellow, variegated and vitreous sulphurets, with quartz and calcspar in 4 parallel bands in chlorite and micaceous slates. Various trial shafts and costeeming pits have been excavated on the deposits." (G.S.C., 1866, p. 300.)

"In the township of Shefford, mining was carried on at two places only, viz., by the Glencoe Mining Co., on lot *seventeen*, range II, where the different ores occur with quartz and calcspar in four separate bands in micaceous and chlorite slate, and on lot 28, range XXIII, by the Waterloo Mining Co......" (R. W. Ells in G.S.C., 1888-89, 39k; also in G.S.C. Bulletin on Copper No. 882, p. 34.)

It is obvious that by mistake the later reports have stated that the operations of this company were performed on lot 17 instead of lot 27. Lot 17 was visited by the writer, where it was found that no prospecting work had been done.

On lot 27, range II, Shefford, a shaft was sunk to a depth reported to have been eighty feet. At the bottom of the shaft it is said that a cross-cut was driven for 12 or 15 feet to the east, and also a short drift toward the north. The country rock is chlorite schist, striking N. 12 degrees E. and dipping about 50 degrees toward the west. The chlorite schists are traversed by a few veins of quartz, siderite and chlorite that trend parallel to the schistosity. From an examination of the dump, it is evident that none of these veins attain a width of more than 6 or 7 inches; that some of the vein material contains a few scattered grains of chalcopyrite, bornite and iron pyrites; that, to a very minor degree, the schist in places adjacent to these small veins, are impregnated with a few grains of sulphides. There is nothing connected with either the shaft or adjacent exposures that suggests the advisability of further work being done.

The Waterloo Mining Co., Range III, Lot 28, Shefford.—In G.S.C., 1866, p. 301, reference is made to this lot as follows:—"Yellow variegated and vitreous sulphurets in micaceo-chloritic slate. A shaft has been sunk to a depth of 60 feet."

Ells repeats this information in G.S.C. 1888-89, p. 39k, and in G.S.C. Bulletin on Copper, 1904, p. 34.

Near the western boundary of this lot, about three hundred yards from its northern boundary, a shaft was sunk to a depth of 12 or 15 feet. Rubbish has accumulated so that, at present the shaft is about ten feet deep. An irregular vein, composed chiefly of quartz with some ankerite and a little chlorite, contains a very few scattered grains of chalcopyrite, bornite and pyrite. On the northern wall of the shaft, the vein is 16 inches wide at surface and gradually decreases in width as it descends. For a few inches from the vein, the schists in places contain finely disseminated grains of pyrite. As a mining prospect, it is of no value.

STUKELY TOWNSHIP.

Apart from a little work that followed the emptying of an old shaft on lot 8, range VII, ten or twelve years ago, in so far as could be learned, no prospecting for copper has been done in this township since 1862-67. In addition to being described in the reports of the Geological Survey, Ottawa, all of the properties from this township discussed in this report are mentioned in the "Partial List of Copper and Sulphur Properties in the Eastern Townships," published in 1902, by J. R. Woodward of Sherbrooke. There is on record a shipment of four to five tons of twenty per cent copper ore from lot 10, range VI. but "more than 700 tons of rock were raised" in order to produce this amount. Exact information could not be obtained but it seems probable that a few tons of ore also may have been shipped from lot 6, range I. From the other properties visited it is not believed that any ore was sent to market.

"The Grand Trunk Mine" —*Range I, Lot 6, Stukely.*—"In Stukely on the seventh and eighth lots of both the first and second ranges, copper pyrites is described as occurring in a band of limestone interstratified with slates. An excavation in one place to a depth of ten feet showed promising quantities of the ore." (G.S.C., 1863, p. 721.)

This mine is on the southeast quarter of the sixth lot of the first range of Stukely. According to Mr. C. Robb, mining engineer, the ores consist of the purple and yellow sulphurets which are disseminated in a breadth of several feet in micaceous and chloritic slates interstratified with dolomitic limestone. The purple sulphurets occur in rich bunches chiefly in the dolomite, while the yellow is disseminated in fine grains in the slate. The richest part of the breadth is immediately near the junction of the two rocks, and the largest quantity of ore is obtained where these are intersected by reticulating veins of quartz. A shaft has been sunk in the deposit to the depth of fifty feet, and large piles of good ore have been obtained from it. While the general dip of the rock is N. 65° W.<50°-60°, the ore in the shaft probably from some twist in the stratification, appears to run vertically." (G.S.C., 1866, p. 34.)

"A shaft was here put down to a depth of sixty feet on a band of yellow and variegated sulphurets, in micaceous and chloritic slates, with dolomite of the usual character. The same bed with a thickness of three feet was found on the lot adjoining; some good ore was obtained but the quantity is unknown." (R. W. Ells in

G.S.C., 1888-89, p. 39k; also in G.S.C. Bulletin on Copper, 1904, p. 34.)

The old shaft referred to in the above quotations as being fifty or sixty feet in depth is situated quite near the boundary between lots 6 and 7, range I, and one to two hundred yards north of the Canadian Pacific Railway. Here, massive beds of marmorized "dolomitic" limestone intercalated with thinner bands of chlorite schists, that originally were shales or fine-grained sandstones, are traversed by reticulating veinlets of quartz, up to a few inches in width. The sedimentary rocks strike northeast and dip about 60° to the northwest. The small irregular quartz veins, as well as the marmorized limestone and chlorite schists adjacent to the veins carry disseminated grains of chalcopyrite, pyrite and bornite. The approximately vertical position of the quartz veins explains the statement of Richardson that "the ore appears to run vertically," for it is certain that the copper minerals were brought in by the solutions that formed these small veins.

The shaft is situated upon the same belt of limestones as that on lot 8, range II, Stukely, where a marble quarry has been opened by the Dominion Marble Company. Five other small openings up to eight feet in depth were made in the vicinity of the shaft. Trees have grown up since the work was suspended, and some of the dumps are concealed by grass. South of the shaft, some fairly good specimens of crystalline limestone, impregnated with scattered grains of quartz, chalcopyrite, pyrite and bornite may be dug out of the dump. None of the fragments would run more than from three to four per cent in copper. In character, the ore is similar to that from lot 9, range II, of Ely township. Unfortunately, no information could be gained concerning the interior of the shaft which is now full of water. Examination of the dump and of the adjacent outcrops shows that the copper values were very irregularly distributed within a small irregular patch where the reticulating veinlets of quartz were apparently somewhat more abundant than elsewhere in the vicinity. The reference by Richardson to "large piles of good ore" suggests that a few tons may have been shipped from here. It does not seem at all probable that from this shaft copper ore could be produced at a profit.

Range I, Lot 7, Stukely.—About 250 yards north of the C.P.R., and about 150 yards east of the boundary between lots 6 and 7, an opening has been made to a depth of a few feet in limestone and chlorite schists traversed by reticulating veinlets of quartz and calcite carrying a few very widely scattered grains of pyrite. The rocks are the same as those referred to in the preceding description of lot 6, range I.

Lambe and Shepherd's Mine, Range II, Lot 7, S.W. ¼, Stukely. —"On the south half of the seventh lot of the second range of Stukely, a shaft has been sunk to a depth of 21 feet on the same run of rocks (micaceous and chloritic slates interstratified with dolomitic limestone). Through the whole of the dolomite which is from fifteen to twenty feet thick, yellow copper ore mingled with iron pyrites is more or less disseminated, while vitreous sulphurets of copper is present in the micaceo-chloritic slates. The general attitude and aspect of the strata at this place resemble those of the Grand Trunk mine." (James Richardson in G.S.C., 1866, p. 34.)

"Yellow sulphuret with iron pyrites, disseminated in a breadth of 15 to 20 feet of dolomite limestone; also vitreous sulphuret in micaceous and chloritic slate. A trial shaft of 21 feet in depth has been sunk and other exploratory work performed. Owners—William B. Lambe and Jacob Shepherd." (G.S.C., 1886, P. 301.)

Under the title of Lambe and Shepherd's Mine, Ells repeats this information:—"A trial shaft, 21 feet deep, was also sunk by Messrs. Lambe and Shepherd in the south half of lot 7, range II, on a band of 15 to 20 feet of dolomite, carrying disseminated yellow ore with pyrites." (G.S.C., 1888-89, p. 39k; also in G.S.C. Bulletin on Copper, No. 882, 1904, p. 34.)

Here, impure dolomitic limestone, striking N. 40° E. and dipping about 60° to the northwest is traversed by a few small irregular veins of quartz up to four inches in width containing small crystals and grains of pyrite with occasional particles of chalcopyrite. Adjacent to the veins, a few irregularly scattered grains of these sulphides are present in the limestone. No work has been done since the writing of Richardson's report in 1866. Very few are the grains of chalcopyrite that now can be found, either in the fragments on the dump or in the exposures at the collar of the shaft, which is now full of water. Indications do not warrant the revival of prospecting operations.

The Logan Mine, Range IV, Lots 9, S.E. ¼ and 10 S.W. ¼ Stukely.—"On the ninth and tenth lots of the sixth range, two excavations have been made, one 15 feet long and 30 feet deep on the slope of the bed, which is to the northwest, at an angle of forty-five degrees. From these pits more than 700 tons of rock were raised, which gave a few barrels of marketable ore, but too little to pay the expense of working." (Sir Wm. Logan in G.S.C., 1863, p. 722.)

"On lot 9, S.E.¼, vitreous sulphuret in chloritic sandstone; the ore is associated with quartz, feldspar and chlorite, and in an open cutting along the vein masses of pure ore weighing from 3 to 12 pounds, have been obtained.

On lot 10, S.W.¼, ore and rock of the same character being a continuation of the previous. This run of ore on the two lots constitute the Logan mine in which from 4 to 5 tons of 20 per cent ore have been obtained." (G.S.C., 1866, p. 301.)

"On the south-east quarter of lot 9, and the southwest quarter of lot 10, range VI, vitreous sulphuret occurs in chloritic sandstone associated with quartz, feldspar and chlorite; masses of pure ore being obtained of from three to twelve pounds weight. On the latter area, the Logan mine was located in which from four to five tons of twenty per cent ore were obtained." (R. W. Ells in G.S.C., 1888-89, p. 39k; also in G.S.C., Bulletin on Copper, No. 882, 1904, p. 34.)

A comparison of the above quotations will show that the more recent reports have mentioned the production from this property of "four to five tons of twenty per cent ore," but have omitted the fact that "more than 700 tons of rock were raised." This omission explains the statement of the man living upon the property that "it is surprising how many mining men have visited the mine."

Here chlorite schists strike to the northeast and dip 40° to 50° toward the northwest. About twenty yards from the road between ranges V and VI and in the southeastern corner of lot 9, range VI, an opening has been made to a depth of 12 feet and a trench 30 feet in length with a depth of about 6 feet extends from it transverse to the strike of the schists. A few yards to the westward another opening has been made to a depth of 15 feet. On lot 10, range VI, close to its western boundary, there is a large opening, approximately 16 feet square; apparently this is the excavation referred to by Sir William Logan in 1863, as being 30 feet deep on the slope of the bed.

Parallel to their schistosity, the chlorite schists enclose small irregular lenses, a few inches in width and a few feet in depth, composed of granular calcite and quartz and carrying some chalcocite, bornite, a little pale yellow zinc blende, and occasionally, numerous small grains and octahedral crystals of a spinel of a beautiful light blue colour. These vein-like streaks are much too few and scattered to constitute a serious mining proposition.

Range VII, Lot 8, Stukely.—"On the eighth lot of the seventh range, copper ore occurs in two bands of dolomite, dipping to the northwest; one of these is about 30 feet wide. The second, which is greenish and chloritic, holds variegated and vitreous ores in larger quantities than most of the localities observed in this vicinity." (G.S.C., 1863, p. 722.)

In the G.S.C., 1866, p. 302, range and lot numbers have been confused, for it is plain that what is there reported from range VIII, lot 7, pertains to range VII, lot 8. This report reads as follows:—"Vitreous sulphuret in two parallel bands of dolomite, which are 23 and 36 feet respectively, separated by about 175 yards of micaceous and chloritic slate. In these dolomites, the ore is more immediately associated with veins and strings of quartz, calcspar, chlorite and epidote. A good deal of exploratory work has been done on the lot; a shaft has been sunk 60 feet, and a cross cut driven 12 feet to the west, near the bottom, which is not far enough to reach the ore."

With a repetition of this error as regards the numbers of the range and lot, the same information is given by Ells in the G.S.C., 1888-89, p. 39k and in the G.S.C. Bulletin on Copper, No. 882, p. 34.

As described above, two bands of bluish-grey impure dolomitic limestone cross this lot, striking northeast and dipping steeply to the northwest. Locally the limestone is traversed by reticulating veinlets of quartz with a little calcite and chlorite. Within portions of these veinlets and in the limestone adjacent to them a few scattered grains or small nests of chalcocite and bornite may be found. Toward the middle of the lot, in places where such veinlets are present, considerable prospecting work has been done. In the western band of limestone, a small open cut, and in the eastern band, an open cut and three shafts failed to disclose anything of economic value. The copper minerals are too irregularly distributed and the quantity is far too small to justify the amount of work that has been performed. Two of the shafts are about eight and fifteen feet deep, respectively. The deepest shaft is vertical and according to the man who owns the surface rights, is about 100 feet in depth; about 80 feet down a cross-cut extends to the west for about 16 feet. Ten or twelve years ago the water was taken from the shaft, and a few blasts were discharged in the face of this cross cut.

Range VIII, Lot 8, Stukely.—"Vitreous sulphuret in two parallel bands of dolomite." (G.S.C., 1866, p. 302.)

Although not mentioned by Ells in his report of 1888-89, a symbol is placed upon his map to indicate that copper ores had been found upon this lot.

Approximately four hundred yards north of the road between ranges VII and VIII and near the eastern boundary of this lot, three small openings were made to depths of five, six and seven feet respectively within a distance of forty yards along a band of dolomitic limestone, striking N. 40° E. and dipping steeply to the northwest. The limestone is intersected by a few small irregular stringers of quartz with a little calcite, one of which was observed to attain a maximum width of six inches. From an examination of the exposures and of the rock fragments from these openings, it is evident that within portions of these veins and in the limestone immediately in contact with them, a few grains of chalcocite occasionally may be found.

Range IX, Lot 5, Stukely.—In the Geology of Canada, 1863, p. 722, it is stated that "copper has been noticed" in the form of "small quantities of variegated and vitreous ores in a gangue of quartz, with feldspar and bitter spar in chloritic slates" upon this lot.

"Vitreous sulphuret and green carbonate in considerable quantity in chloritic slate." (G.S.C., 1866, p. 302.)

To the north of the road that crosses the northern portion of this lot a shaft has been sunk on the slope to a depth of "about 25 or 30 feet" in argillaceous sediments that have been partially converted to chloritic slates or schists, striking No. 40° E, and dipping about 75° to the northwest. A few braided veinlets, of quartz with a little orthoclase and calcite, each less than three inches in width, carry a few widely scattered grains of chalcocite. The shaft has been filled with rubbish.

Range IX, Lot 6 (N. E.¼), Stukely.—"Variegated and vitreous sulphurets in slate; a shaft has been sunk to the depth of 142 feet. Owned by Thomas Solomon." (G.S.C., 1866, p. 302.)

Evidently basing his statement upon the above quotation, Ells writes:—"On the north-east half of lot 6, range nine, a shaft was sunk for 142 feet in a slate band carrying similar ores to the last (variegated and vitreous sulphurets in veins and strings of quartz, calcite, chlorite and epidote) but without satisfactory results." (G.S.C., 1888-89, p. 39k; also in G.S.C. Bulletin on Copper 1904, p. 34.)

Although this statement has been repeated in the above publications, the writer is thoroughly convinced that no shaft exists on this lot. Nor does it seem probable that a prospecting shaft, 142 feet in depth, exists anywhere within Stukely township. This was the conclusion drawn from interviews with those living upon this and adjacent lots, as well as with some of the oldest residents.

That which is known locally as Solomon's mine, a description of which immediately precedes this, is situated on range IX, lot 5.

Range X, Lot 4, S½, Stukely.—In the Geology of Canada 1863, p. 722, it is mentioned that "copper has been noticed" upon this lot.

"Vitreous sulphuret and green carbonate with much hydrated peroxyd of iron, associated with quartz, calcspar, and feldspar, enclosed in chloritic slate. Four cupriferous bands occur in breadth of between 80 and 90 paces. A shaft has been sunk to a depth of 22 feet." (G.S.C. 1866, p. 302.)

"On the south half of lot four, tenth range, a shaft 22 feet deep was sunk in order to cut a band of eighty to ninety paces, in which four cupriferous bands occur." (G.S.C. 1888-89, p. 39k; also in G.S.C. Bulletin on Copper, 1902, p. 35.)

Not far from the southern boundary of this lot and just west of the road crossing the southeastern corner of this lot, a shaft has been sunk in what were considered as originally having been argillaceous rocks that have been partially converted to chlorite schists, striking northeast and dipping very steeply toward the northwest. No work has been done since the above report was written in 1866. Nothing analogous to "four cupriferous bands" could be distinguished by the writer. The partially schistose rocks are traversed by irregular stringers of quartz, orthoclase and calcite. Within portions of some of these veinlets, the feldspar is the predominant mineral. In portions of at least some of these small veins, a few grains of chalcocite and bornite occasionally may be found.

Ely Township.

In so far as could be ascertained, the only shipments of copper ore from this township have been "several barrels of ore" from lot 9, range II and a few tons of comparatively rich ore from lot 3, range VII.

Range I, Lots 11 and 12, Ely.—"Lot 11—yellow and variegated sulphuret in dolomitic limestone.

"Lot 12—yellow sulphuret thinly disseminated in crystalline limestone." (G.S.C. 1866, p. 304.)

Although not mentioned by Ells in his reports, symbols indicating the presence of copper upon these lots are placed on the map accompanying G.S.C., Vol. VII, 1894, part J.

Apparently no prospecting work has been done on lot 11, range I, nor did the writer observe any indications of the presence of copper-bearing minerals.

On lot 12, range I, a shaft has been sunk in chlorite schists containing some disseminated grains of an iron-bearing carbonate, probably ankerite. The old gentleman now living upon this lot stated that prior to being filled up with rocks the shaft was about 20 feet in depth. A careful search did not reveal the presence of a single particle of any of the copper-bearing minerals either in the bed rock or within the loose fragments scattered in the vicinity of the shaft.

Ely Copper Mining Co., Range II, Lots 9 and 10, Ely.—"Here is a band of white and grey dolomite about 40 feet thick which appears to be overlaid by a bed of talco-chloritic slate. The copper ore, consisting of the purple and yellow sulphurets, is partly in the dolomite and partly in the slate, which holds a good deal of white quartz in irregular strings and veins. The ore occupies a thickness of about five feet, and as far as I could judge, these five feet may hold about two per cent in metallic copper. At the time of my visit in 1864, a shaft of ninety-seven feet had been sunk in the deposit, and I believe the work was soon after suspended." (James Richardson in G.S.C. 1866, p. 35.)

The above information is repeated in G.S.C. 1866, p. 304.

"In the township of Ely, though indications of ore are found at a number of points, the principal deposit was on lots 9 and 10 of the second range, owned by the Ely Copper Co., where the ores were the yellow and variegated sulphurets in a crystalline limestone." (R. W. Ells in G.S.C. 1888-89, p. 33k; also in G.S.C. Bulletin on Copper, No. 882, 1902, p. 28.)

The old shaft of the Ely Mining Company is situated on lot 10, range II, in the village of Racine and less than a hundred yards to the east of Orford Mountain Railway (now the C.P.R.) The shaft penetrates impure crystalline dolomitic limestone interstratified with micaceous schists, the metamorphic equivalents of argillaceous rocks, striking northeast and dipping 60° to 65° to the northwest. Although outcrops are quite widely scattered, the shaft must be within a few yards of the contact of these sedimentary rocks with the body of chloritic schists (originally igneous rocks of the composition of a fine-grained diorite or diabase), that lies to the north, and typical exposures of which may be seen at various point in Racine Village.

The crystalline limestone and micaceous schists are traversed by narrow irregular quartz veins, up to four or five inches in width. Some portions of these quartz veins carry a few scattered grains of chalcopyrite and pyrite. Adjacent to these veins, both the limestone and also to a much less degree, the mica schists are impregnated with disseminated grains of these sulphides. In addition, within two fragments of the mineralized limestone, a few small particles of galena were observed to be present. It is plain that the solutions forming the quartz veins carried with them these sulphides. Fragments upon the dump show that the mineralization has been very irregular and is best displayed in the limestone, for a few inches on either side of an intersecting stringer of quartz. In general, the sulphides are sparsely disseminated. From a Mr. Corriveau, who worked in this shaft, it was learned that they reached a depth of 100 feet, and from the bottom, drifts extend for about 15 feet in either direction. In the drifts, the sulphides were practically absent, but this gentleman was much concerned about a "stringer, approximately two inches in width, carrying much yellow copper (chalcopyrite) that was left in the bottom of the shaft." Operations must have been suspended a few months after Richardson's visit in 1864, a year during which, copper was selling at from 39 to 55 cents a pound. At that time several barrels of ore were shipped by team to the railroad at Waterloo.

Within less than a hundred yards northeast of the shaft, two small openings, each with a depth of a few feet, and a trench to bed rock, about 100 feet in length, were excavated, but revealed no evidences of mineralization. Much rubbish has been thrown into the shaft.

Range III, Lot 12, Ely.—"Yellow sulphuret and green carbonate in chloritic slate." (Geol. Surv. of Can. 1866, p. 305.)

A symbol indicating the presence of copper upon this lot is placed on the geological map of the Eastern Townships accompanying Part J, Vol. VII of the G.S.C.

Upon the western slope of a low ridge a trench, thirty feet in length and with a maximum depth of eight feet, has been driven transverse to the cleavage of chloritic slates, the metamorphic equivalents of shales. The slates are traversed by irregular quartz veins, approximately parallel to their schistosity, which strikes N. 52° E. with vertical dip. Within the trench, the few narrow quartz veins exposed do not exceed six or seven inches in width; elsewhere on the ridge a similarly irregular vein was observed to attain a width of eighteen inches. One must search patiently in order to find a few grains of pyrite within the quartz. One or two bands of the slate, two to three inches in width, also contain a few small crystals of pyrite.

The Ely Mine—Range VII, Lot 3, Ely.—In the G.S.C., 1879-80, pp. 17H and 19H, the following record of an assay from this property appears:—"This specimen was examined for Mr. J. R. Woodward; it was not asserted to be an average sample. It consisted of chalcocite in a gangue of dolomite and quartz and contained: Copper—46.14 per cent, Gold—traces, Silver—1.094 ounces to the ton of 2,000 lbs."

In the G.S.C., Vol. XV, 1902-03, p. 310A, the Ely mine is mentioned as "previously worked mine" that has been "recently re-opened to some extent."

"This property is a mile distant from the Orford Mountain (since March, 1910, a branch of the C.P.R.) railway, and consists of 200 acres in fee simple, on which is the mine, and mining rights over 3,200 additional acres, all in the township of Ely. Considerable work has been done. The vein has been traced over half a mile."—(Partial List of Copper and Sulphur Properties in the Eastern Townships, by J. R. Woodward, of Sherbrooke, November, 1902.)

The shaft on this property is about a mile and a half from the Orford Mountain railway; but, in order to reach it with a team one must drive between four and five miles westward from Valcourt station. The major portion of the lot is now occupied by bush and bramble, through which a rough trail extends to the shaft. Toward the eastern end of the lot, a low ridge of quartzite strikes N.E.-S.W., and dips steeply to the southwest. The quartzite is white in colour, and is composed chiefly of grains of quartz and feldspar in a siliceous cement. Undoubtedly this occurrence is the southwestern extension of that band of quartzite which Dresser assigned to the Ordovician, and which, outcropping a few miles west of Richmond, may be traced southwestward through Melbourne township where it was observed on Galop Hill and at the so-called "Bower's mine" on lot 7, range I, Melbourne.

This prospect is held by Mr. J. R. Woodward of Sherbrooke, the author of the "Partial List of Copper and Sulphur Properties," so frequently referred to in the present report. It was discovered in 1865, at which time a shaft was sunk to a depth of about 25 feet. In 1881, the shaft was extended to a depth of 55 feet; and 3.07 tons of 9.2 per cent, 6.88 tons of 8 per cent and 0.55 tons of 6.6 per cent copper ore were taken by team to Acton Vale station, 18 miles distant, and shipped to the Orford Copper and Sulphur Company then at Capelton. In 1901, the shaft was extended to a depth of 75 feet. Mr. Woodward states that in that year he sent to Mr. Herbert Carmichael, of Boston, a very rich mass of grey copper ore weighing 1,156 lbs. which carried 57.84 per cent of copper and 535 lbs. containing 26.77 per cent.

The inclined shaft penetrates an irregular lenticular body of impure "dolomitic" limestone, enclosed within the quartzite. The maximum dimensions of the limestone could not be exactly determined, but it probably does not exceed 7 to 9 feet in width, while if drifts were extended from the shaft in either direction they would within a very few feet pass from the limestone into the quartzite. At intervals for a few hundreds yards, southeastward from the shaft some small excavations have been made in the quartzite. In some of these one or two minute veinlets of calcite and quartz carrying a few grains of chlorite intersect the quartzite. In a trench a few feet southeast of the shaft, two such irregular veinlets, each less than an inch in width, may be seen.

At the shaft, the limestone is highly crystalline, white in colour, and contains considerable silica. Within a narrow band of the limestone, some particles of chalcocite and bornite are dispersed with a tendency to a linear arrangement, roughly parallel with the regional strike. In one streak, up to nearly an inch in width, these particles in places are sufficiently abundant to cause it to have the appearance of a veinlet of the copper-bearing minerals.

In thin section under the microscope, it is plain that the chalcocite has developed from bornite through processes of secondary enrichment. Small irregular kernels of bornite are present within some of the grains of the chalcocite. It seems possible that with depth the bornite may be found to have been derived from smaller amounts of chalcopyrite. In part, the calcite has been irregularly replaced by quartz. Some minute cracks are stained with reddish oxide of iron.

The shaft was partially filled with old timbers and water. From many of the other openings yet made on the property it is certain that nothing of commercial value has been discovered. Judging from the character of the ore, its mode of occurrence and the relatively small quantity of it in comparison with the amount of rock to be handled, it seems most improbable that work in the shaft would be profitable.

MELBOURNE TOWNSHIP.

In so far as could be learned, no copper ore, apart from a few bags of samples, have been shipped from this township. Frequent reference is made in literature to the properties here described; of these one hears most frequently of the "Balrath mine" on range IV, lot 2.

"*The Bowers Mine*"—*Range I, Lots 7 and 8, Melbourne.*—On range I, lot 8, Melbourne, a good deal of exploratory work has been done in pits and trial shafts." (Geol. Surv. of Can. 1866, p. 311.)

"Considerable exploratory work was also done on lot 8, range I, in the shape of pits and trial shafts on a deposit of yellow sulphurets; the copper being mixed with magnetic and specular iron ore in a gangue of quartz and calcspar cutting quartzite and talcose slates.'' (R. W. Ells in Geol. Surv. of Can. Vol IV, 1888-89, p. 40k; also in Geol. Surv. Bull. on Copper, No. 882, 1904, p. 35.)

"For two seasons Mr. F. E. Bowers of Chicago has worked a new property on lot seven of the first range of Melbourne. At my visit in June last, a shaft, seven and a half feet square, was sunk vertically to a depth of fifty feet in a quartz mass, which carried copper pyrites and bornite in stringers in the quartz through about one fourth of its width. Assays of the chalcopyrite were said to give twenty-four per cent copper, 32 per cent sulphur; of the bornite 19 per cent each of copper and sulphur. There was also $9 worth of gold to the ton." (J. A. Dresser in G.S.C. Vol. XV, 1902-03, p. 309A.)

Here massive beds of white quartzite, striking N. 54° E. and dipping steeply toward the northwest, are exposed for a width of about one hundred and fifty feet. Very white in colour and uniform in grain, these beds of quartzite may be followed northeastward across Galop Hill, to the St. Francis river just west of Richmond. What is undoubtedly the same quartzite was observed at the Ely mine (range VII, lot 3, Ely township), where it encloses beds of a dolomitic limestone, that through pressure has been rendered crystalline and now appears as narrow bands and lenslike bodies within the quartzite. It was in limestone, in similar relationship to this quartzite series, to the north of Richmond that Mr. Dresser found fragments of crinoid stems, that led him to assign an Ordovician (Calciferous-Chazy) age to these rocks.

At the Bowers mine, the shaft on lot 7 is vertical and is situated near the eastern margin of the quartzite, where it is interbedded with a few thin layers of what originally was shale or a fine-grained sandstone, now converted into chlorite schist. A specimen of the quartzite examined in thin section under the microscope was found to be composed chiefly of grains of quartz with a few of feldspar (both orthoclase and plagioclase), a few flakes of sericite and occasional minute crystals of zircon and rutile. Under the action of pressure, the rock has been granulated, and percolating solutions have deposited a few widely scattered grains of calcite. At some future date, portions of this thick band of quartzite may be utilized by commercial projects seeking a rock that is very rich in silica and free from iron.

The quartzite is here intersected by irregular gash-like stringers composed of milky quartz and a little calcite, carrying some pyrite, chalcopyrite and small octahedral crystals of magnetite. Judging from fragments on the dump, the quartzite, for a few inches in width adjacent to the vein, occasionally is impregnated with these minerals. At the surface the widest of the veins was about six inches in width but narrowed with depth. All of the veins lack continuity.

Worked twelve years ago, the shaft, which is fifty feet deep, is now full of water. One of the men who worked in the shaft stated that work was suspended because they did not find sufficient ore. Only a few small bags of samples were shipped from the property.

About 100 yards south of this shaft, an older shaft was sunk about forty to fifty years ago on lot 8. The shaft is vertical and penetrates chlorite schists, traversed parallel to their schistosity by a very few narrow veinlets of quartz and calcite. Portions of these stringers carry a little pyrite and a few particles of chalcopyrite. Judging from the size of the dump, which now is partially concealed by vegetation, this old shaft must be approximately thirty feet in depth.

The Coldspring Mine,—Range II, Lot 6 Melbourne.—Specimens of "variegated and vitreous sulphuret of copper from a bed" on this property were exhibited at the London International Exhibition of 1862. In the Descriptive Catalogue of the Economic Minerals of Canada (p. 15), issued upon that occasion, the following description of this property is given—"The bed from which these specimens are derived is composed of quartz and nacreous slate, in which the ore is disseminated in thin interlocking lenticular patches, and in grains; as in the beds of Harvey's Hill mine. The dip of the strata is northwestward, at an angle of about forty-five degrees. Last summer a shaft was sunk to cut the bed at seven fathoms, but none of the ore has yet been stoped. In a breadth of 120 feet across the strata, on the one side of the shaft and 80 feet on the other, there are several parallel bands of cupriferous strata, marked chiefly by the green carbonate of copper, but showing occasional indications of the variegated and vitreous sulphurets. What the productiveness of the ground may be, has, however, not yet been ascertained.

"At the Coldspring mine on the sixth lot of the second range, the strata dip to the northwestward at an angle of about 45 degrees and exhibit in a breadth of 200 feet several parallel bands in which the quartzose mica slate is coloured green by carbonate of copper and contains portions of the vitreous and variegated ores disseminated in grains and lenticular masses. A shaft has been sunk here which intersects one of the beds of a depth of six fathoms and several trenches have been made across the beds. A vein yielding rich specimens of vitreous copper is also described as here cutting the strata at a small angle. Some of the beds of slate, just noticed, like those of Sutton, contain sulphuret of copper in a state of minute division. Such a band impregnated with the vitreous ore, gave, according to Mr. Robb's assay, seven per cent of copper." (G.S.C. 1863, p. 723.)

In the Geology of Canada, 1866, p. 38, this property is mentioned as "the Coldstream Mine." In the list of copper localities which appears as an appendix (p. 311) in the same volume the following statement appears:—"Variegated and vitreous sulphurets in nacreous slates and quartz. In 200 feet across the strata there are several bands of the ore. A shaft has been sunk to some depth. This is the Coldspring Mine, owned by Thos. Mackie & Co."

"At the Coldspring mine, lot six, range two, some shafting was done, the ore occurring in narrow bands over a considerable width but not in sufficient quantity to be economically valuable." (G.S.C. 1888-89, p. 40k; also in G.S.C. Bulletin on Copper, No. 882, 1904 p. 35.)

Approximately the northern two-thirds of this lot is high ground and is clothed with hardwood varieties of trees; the lower ground of the southern one-third is occupied chiefly by spruce and balsam. Prospecting operations were carried on in the northern portion of the southern half of the lot. Three shafts, concerning the depth of which definite data was not obtained, were sunk in chlorite schists, the metamorphic equivalent of a fine-grained igneous rock of the composition of an andesite or diorite. The general strike of these schists is N. 50° E. and they dip 45° to 55° to the northwest. These shafts are reputed to have depths of nearly 100 feet, 40 to 50 feet, and 25 feet respectively. The two deepest shafts are approximately on strike, about 100 feet apart, and between them, another opening has a depth of about ten feet. The third shaft is on higher ground, about 200 yards removed to the westward. In addition considerable trenching to bed rock has been done.

Narrow irregular veins of quartz, feldspar, chlorite, calcite and ankerite traverse the schists, usually parallel with but occasionally oblique to the schistosity. In no instance were these veins or stringers observed to have a length of more than a few yards or to exceed five inches in width. The feldspar in these veins is frequently graphically intergrown with the quartz. Occasionally it occurs within the quartz as long narrow crystals, sometimes less than a quarter of an inch in width and six or seven inches in length. Twinning of these long narrow crystals then causes the feldspar to assume a fibrous or bladed appearance. Apparently it is identical with the adularia or valencianite described by various writers as occurring as a gangue mineral from numerous mining centres in the western United States and Mexico. In portions of these veins and in their vicinity within bands of the schist, a few inches in width, a little specular hematite, chalcocite and bornite are occasionally present. When we consider how widely separated are the narrow veins and streaks where these minerals occur, and in what small quantity the copper minerals are present in any vein or streak, it is surprising that such extensive prospecting work was done. No ore was shipped from this property.

The Rahell (*Ryan*) *Hill Mine—Range III, Lot 2.*—Under the name "Ryan Hill mine" this property is referred to in the G.S.C., 1866, p. 311, as follows,—"On range 2, lot 2, Melbourne—variegated and vitreous sulphurets in chloritic slate. The minerals belong to T. Frizzell and George Doudall."

"The Ryan Hill mine is situated on lot two, range two; the ore is the variegated and vitreous sulphuret in chloritic slates; the size of the band not being stated." (G.S.C. 1888-89, p. 40k; also in G.S.C. Bulletin on Copper, 1904, p. 35.)

Locally this scene of prospecting operations of about fifty years ago has not been known as the Ryan Hill but as the Rahell Hill or Frizzell mine. Although the blacksmith shop and other buildings then stood on the northeastern corner of range II, lot 2, mining endeavour was restricted to the south eastern corner of range III, lot 2. Here on the western slope of a steep hill of chlorite schists a tunnel, 60 feet in length, was driven toward S. 20° E. The chlorite schists strike approximately N. 45° E., dipping steeply to the northwest. For a distance of 45 feet within the tunnel, the chlorite schists are traversed by seven small irregular veinlets of quartz, white feldspar and calcite, five of which are each less than an inch in width; another is locally three inches wide, tapering to a point at the roof of the tunnel, while the seventh and innermost, possessing an average width of about three inches, was observed to contain a few minute specks of specular iron ore. The remaining 15 feet of the tunnel traverses uniform chlorite schist. Some trenching was done on the surface of the hill immediately above, but the very few veinlets observed were as small and barren as within the tunnel. Upon the dump no trace of ore was observed. The lot is now covered with a healthy second growth of trees, chiefly of hardwood varieties.

"*The Balrath Mine*"—*Range IV, Lot 2, Melbourne.*—"Here the cupriferous strata include a vein from two to four feet wide, which is described as conformable to the stratification and as consisting of quartz and calcspar, carrying in certain proportions considerable quantities of variegated copper ore. A trench 20 ft. long and 18ft. deep was first dug on the strike of the vein, and a shaft then sunk to about 50 feet, from which about a ton of good ore was obtained. Four other smaller openings, parallel to this, afforded indications of copper." (Geology of Canada, 1863, p. 723.)

In the report, Geology of Canada, 1866, p. 311, there appears the following:—"Variegated and vitreous sulphurets in a gangue of quartz calcspar and feldspar in eight beds in chloritic slate, varying from 1½ to 5 ft. in width. A shaft has been sunk on one of these about 2 feet wide to a depth of 100 feet showing bunches of rich ore irregularly distributed."

"At the Balrath mine on lot two, range four, the ore, which is of the kind just described (variegated and vitreous sulphurets in chloritic slates) is said to occur in a series of bands, eight in number, ranging from one and a half to five feet in width, in one of which a shaft was sunk which disclosed some rich bunches of ore. (G.S.C. Vol. IV, 1888-89, p. 40k; also in G.S.C. Bulletin on Copper, No. 882, 1904, p. 35.)

In G.S.C. Vol. XV, 1902-03, p. 310A, the Balrath is mentioned as a previously worked mine "which has been recently reopened to some extent."

The country rock is a dark greenish-gray chlorite schist, within some bands of which squeezed phenocrysts of plagioclase up to one-fourth of an inch in length are scattered through the rock. Some of these phenocrysts have been more or less completely altered to chlorite and quartz, while they are usually enclosed by a film of chlorite of darker colour than the rock itself.

In thin sections under the microscope, the rock is found to be a porphyrite composed chiefly of chlorite, some plagioclase feldspar, quartz, considerable sphene, black iron ore and leucoxene. In the field, it was not determined whether these schists are the metamorphic equivalents of a fine to medium grained intrusive or of a lava flow.

These schists strike N. 44° E., dipping steeply to the northwest. The shaft of the Balrath mine is sunk upon a vein, traversing the schists parallel with and in part oblique to the schistosity, which is composed chiefly of granular calcite with some quartz and less feldspar. Very irregularly distributed through the vein are small particles of bornite, chalcocite and occasionally a little specular hematite, which are elongated and distributed in more or less linear arrangement parallel to the walls of the vein. Other veins up to a few inches in width traverse the adjacent schists in an irregular manner. These smaller veins frequently contain less calcite, more quartz and feldspar with specular iron ore arranged in blade-like forms transverse to the vein, and occasionally a little chalcocite and bornite.

Examination in thin section under the microscope shows plainly that the chalcocite has been the result of secondary enrichment, being derived from alteration of the bornite. Strain shadows and sheared and crumpled cleavage planes within the calcite show that the veins have been subjected to some pressure subsequent to their formation.

With the exception of a small portion of its northern end the lot upon which this "mine" is located is occupied by a second growth of trees, chiefly of hardwood varieties. The mine was first worked fifty-two years ago. Inclined at an angle of 60° to 70° toward the northwest, the shaft (now full of water) was sunk to a depth of 102 feet. At a depth of about 30 feet, a drift extends toward northeast about 40 feet, and about 60 feet down a drift has been driven between 70 and 80 feet toward the southwest. Some rich samples of ore were found, but it will be observed that in the Geology of Canada, 1863, it was stated that about a ton of ore had been obtained while sinking the shaft to a depth of 50 feet.

Thirteen years ago this mine was reopened and samples were taken in the bottom of the shaft and in the drifts, while an unsuccessful search was made for a copper-bearing offshoot of the main vein that had been mentioned in an old report. No copper values were found that would warrant further attempts to work this mine.

At a point about two hundred yards from the northwest corner of the same lot, a short distance southeast of the house now occupied by Mr. Z. Croteau, the chloritic schists, striking N. 50° E. and dipping steeply toward the northwest, are traversed by a very irregular vein or dyke of quartz and pink feldspar and a little chlorite. Within the vein, orthoclase is the predominant mineral and both the quartz and feldspar are so coarsely crystallized that if considered by itself, one at once would refer to it as a small pegmatitic dyke rather than a vein. Ramifying branches, a few inches in width, extend from this vein or dyke into the adjacent schists. Within these branches, granular calcite is present with the quartz and feldspar as well as a little chalcocite and bornite. A blast has been discharged in the surface of the vein. The indications do not justify further work being done.

Range IV, Lot 3, Melbourne.—"Yellow and vitreous sulphurets in traces in a gangue of quartz, feldspar and chlorite in chloritic slate." (G.S.C. 1866, p. 311.)

Near the southwestern boundary of this lot, about thirty yards to the east of the main road, a small opening, that may well have been caused by the discharge of a single blast, has been made where chlorite schists are traversed by a small vein which is composed of quartz, pink feldspar and chlorite with a little calcite. So irregular is this small pegmatite-like vein that the surface of the darker chlorite schists appear to have been splashed by the lighter material of the vein. Within a narrow stringer of calcite and quartz less than two inches in width that emanates from this vein a few small particles of chalcocite were found, while a cubical crystal of pyrite, three-fourth of an inch across, was observed within the main portion of the vein itself.

CLEVELAND TOWNSHIP.

Forty to fifty years ago, considerable prospecting for copper was carried on in this township. In so far as could be learned, the St. Francis mine, on lot 25, range XII., is the only property within the township from which copper ore has been shipped. Exact information could not be obtained, but it does not seem probable that the production of copper ore from this mine exceeded a few hundred tons, while much of the gangue of the vein carrying low values in copper was shipped to a smelter at Capelton, where it was used as a flux for other ores.

The St. Francis Mine.— Range XII, Lot 25, Cleveland.— A specimen of "yellow sulphuret of copper from a vein" on the property was displayed at the London International Exhibition, 1862. In the Descriptive Catalogue of the Economic Minerals of Canada (p. 14) prepared by the Geological Survey for that occasion, the mine is described as follows:—"The ore is disseminated in a vein, slightly oblique to the stratification of a quartzo-chloritic rock, frequently studded with nodules of orthoclase feldspar, often surrounding small centres of quartz; the nodules give to the rock the aspect of an amygdaloid trap. The bed has an average thickness of three feet, and the rock is supposed to occupy a higher stratigraphical place than the Acton dolomite. The vein is traced, running N.E. for ninety fathoms. Five or six small excavations, each of a few fathoms in length, have been made in the outcrop, to the depth of two feet, and in these the variegated and vitreous ores are mixed with the yellow sulphuret."

"The St. Francis mine, situated on the twenty-fifth lot of the twelfth range of Cleveland, is in the middle of the second synclinal and is associated with rocks which occupy a higher stratigraphical place in the third division than the deposits of copper ore previously mentioned. As stated, however, in the General Report (Geol. Can. 1863, p. 723), the St. Francis mine occurs in a true vein running slightly oblique to the stratification and cutting chlorite slates; and in this respect appears to be an exception to most of the other mines in the Quebec group. According to information derived from Mr. Francis Bennett, who directs the mining operations, a shaft has now been sunk to a depth of 195 feet, in the course of which several large cavities or vugs were met with in the vein. At a depth of fifty-two feet from the surface an adit level has been driven across the stratification to assist the draining of the mine, and a gallery carried northward in the lode a distance of thirty-six feet. Ten fathoms below this a gallery has been carried in the lode eighty-five feet to the southwest and sixty-five feet to the northeast; in the former part of which, forty-eight feet from the shaft, a rise has been carried up in the back of the lode for twenty feet. Twelve fathoms lower still, another gallery has been carried 113 feet to the southwest and 137 feet the northeast; at the extremity of which a rise has been carried up twenty feet and another six fathoms up, at a distance of sixty feet from the shaft. Two horse-whims have been erected, one to raise the ore and the other to pump the mine. Driven at a walking pace the pump can raise upwards of 400 gallons of water a minute to the adit, which is more than enough to keep the mine dry. In the ten-fathom gallery the ground was compact and hard, but beneath it very soft, being apparently in a state of decomposition. It continues so in the lower or twenty-two fathom level, not costing more than $10 per fathom to drive and $7 or $8 per fathom to stope; what the harder ground costs I am not aware. The lode in the level is grown four to five feet wide, consisting of quartz and other minerals, associated chiefly with carbonates of copper, which of course will not permit of dressing by water. The ores raised and sold have varied from 6 to 26 per cent. the greater portion being from 9 to 11 per cent. The quantity sent away is gradually increasing and at present amounts to about 30 tons per month. Much of the fine material, however, at this time remains on the surface at the mine and the true yield of the lode is estimated by Mr. Bennett to be about 60 tons per month. How much the lode yields per square fathom has not been ascertained."—(James Richardson in Geol. Surv. of Can. 1866, pp. 38-39.)

"Green and blue carbonates with yellow, variegated and vitreous sulphurets and a little native copper in a true lode of 3 feet wide. A shaft has been sunk 195 feet and 513 feet of levels and rises driven in the lode; much of the ore has been sent to market." (Geol. Surv. of Can. 1866, p. 313.)

"This mine differs from the majority of the others that, up to the present time, have been opened up in the Appalachian region, in that it appears to be a true vein which traverses chlorite schists and has been followed to a depth of more than 200 feet. They estimate that in 1866 the average production of this mine has been about sixty-two tons per month of an ore containing about ten per cent of copper, which in part is found in the form of sulphides with quartz, and in part as carbonates." (Translation from "Esquisse Géologique du Canada," Paris Exposition, 1867.)

A specimen of "Bornite, purple copper ore, with malachite" from this mine was displayed at the Colonial and Indian Exhibition, London, 1886, and the description of the property appearing in the Catalogue of the Economic Minerals of Canada (p. 42) published for that occasion, is identical with that which has been quoted above for the International Exhibition, London, 1862.

"At the St. Francis mine, in addition to the usual ores already mentioned (yellow, vitreous and variegated sulphurets of copper), green and blue carbonates are said to occur with a little native copper; the whole contained in a lode three feet thick. A shaft was here sunk for 195 feet, and levels and other works driven for 513 feet along the lode, from which a larger quantity of ore was taken, which, according to Mr. Bennett, the Manager, ranged from six to twenty-six per cent." (R.W. Ells in G.S.C., Vol. IV, 1888-89, p. 40k; also in G.S.C. Bulletin on Copper 1904, p. 35.)

About three miles from the town of Richmond, the shaft of this mine is situated upon the steep eastern slope of a ridge trending northeast to southwest; about forty feet lower, where the abrupt slope terminates, a tunnel, about forty feet in length, extends into the hill to meet the shaft. At the time of my visit, it was possible to pass along this tunnel to the shaft, and enter the drift that extends northeastward along the vein, at this level, for somewhat more than one hundred feet. This drift was followed about fifty feet to a winze now full of water.

Little can be added to the preceding description of Richardson, written in 1866, for, according to Mr. Robert MacArthur, who lives nearby and who worked at the mine whenever it was operated, work was suspended in 1867. The mine was then idle for several years, but was reopened "more than forty years ago" when, for a period of about two years, work was restricted to cleaning out those portions of the vein that were easily accessible in the old workings. During this last period of activity, much of the old dump also was shipped to a smelter at Capelton, because, in addition to carrying low values in copper, the gangue material was useful as a flux for other ores.

A well-defined vein, striking northeast to southwest, and dipping steeply to the northwest, traverses a dark fine-grained igneous rock that displays a tendency to schistosity. Less schistose than the similar rock of the Balrath, Rahell Hill, and Coldspring "Mines" of Melbourne township, the fissure, within which the vein lies, is slightly oblique to the comparatively weak schistosity. In part the rock has a coarsely pseudo-amygdaloidal appearance because of the presence within it of small scattered ellipsoidal nodules composed of feldspar, occasionally with a little quartz. Not observed to exceed an inch in length, and usually less than half an inch in length and a quarter of an inch across, these nodules are often connected by minute reticulating veinlets of quartz and feldspar. It seems plain that they have been developed within the rock by the solutions that formed the vein upon which mining work progressed.

The vein is said to have possessed an average width of three feet. It is composed chiefly of granular calcite with some quartz and feldspar, carrying chalcocite, bornite, chalcopyrite, micaceous hematite, malachite and azurite. Very little chalcopyrite is present. Some pale bluish chrysocolla and a little melaconite were observed in a few fragments on the dump. The malachite and azurite occur chiefly as "staining" of some of the gangue material; of interest, were small fibrous aggregates of dark green crystals of malachite. Along the footwall, quartz and feldspar were in general more abundant than elsewhere within the vein, and associated with these minerals micaceous hematite was frequently present in considerable amount.

Copper values were irregularly distributed in the vein. It is said that to the southwest of the shaft, very little ore was discovered; that northeast of the shaft, the best ore was found in a streak near the footwall, and especially in that portion of the vein "about fifty feet from the shaft at a depth of between ten and twenty fathoms."

Mr. MacArthur, who furnished the information contained in the preceding paragraph, stated that the shaft is about 200 feet in depth and that to the northeast of the shaft the vein is quite cleanly stoped out as far as the drifts extend and down to the lowest level at a depth of about 180 feet. It seems plain that the work performed after the writing of Richardson's report in 1866 was confined to extending some of the drifts to the northeast of the shaft and removing the vein material.

A thin section of a rich specimen of ore, composed of chalcocite and bornite in a gangue of feldspar (adularia), calcite and quartz, shows the chalcocite, bornite and calcite to have been deposited after the feldspar, while the chalcocite has been derived from the alteration of the bornite. The relationship of the very sparsely scattered grains of chalcopyrite to the other copper minerals was not determined; it is probable that the bornite was derived from the alteration of widely scattered grains of chalcopyrite. The occurrence affords an excellent example of secondary enrichment within a vein in which very low copper values were present in the form of a few very irregularly distributed grains of chalcopyrite, possibly accompanied by a little bornite. One would not expect rich ore to extend to great depth in a deposit of this type. Significant is the statement in a letter from Dresser, who examined the copper deposits of the Eastern Townships for the Geological Survey, Ottawa, that:—"The opinion of the best judge of the property, who knew it when in its operation, was that there is little, if any, ore left in it."

The Jackson Mine—Range XIII, Lot 26, S.W¼, Cleveland.— "On the twenty-sixth lot of the thirteenth range of this township, variegated and vitreous copper ores are found disseminated in a bed of chloritic rock twelve inches in thickness, which dips to the northwest at a high angle. A shaft has been sunk upon this to a depth of about twenty feet. Sixty feet to the eastward of this is a cupriferous bed of three feet, and ninety feet to the west another of five feet in thickness. In these, the same ores are more sparingly disseminated in chloritic rock." (G.S.C., 1863, p. 723.)

"Variegated and vitreous sulphurets in white quartz, reddish feldspar and chlorite, with a width of one foot, in chloritic slate. This is Jackson's mine. A shaft of twenty feet in depth has been sunk." (G.S.C., 1866, p. 313.)

"At the Jackson mine, a shaft was sunk to a depth of twenty feet, the ore being found in a lode of a foot in width, with other larger veins, carrying ore in smaller quantity at no great distance." Having described the St. Francis mine immediately preceding this statement, the author continues:—"The amount of ore extracted from either of these places is not known." (R. W. Ells in G.S.C. 1888-89, p. 40K; also repeated in G.S.C. Bulletin on Copper, 1904, p. 35.)

Circumstances did not permit the writer to visit this location, but it was learned from Mr. Robert MacArthur, who worked at the St. Francis mine (on lot 25, range XII) that although the country rock and the gangue material of the vein was similar to that of the St. Francis mine, work was suspended at the Jackson mine because "they did not find enough copper." No ore was shipped from this property.

LEEDS TOWNSHIP.

The Harvey Hill Mine—Range XV, Lot 17, Leeds.— The literature pertaining to this property is far too extensive to repeat in this report. Anyone desirous of becoming familiar with the details of what has been written concerning this mine should read:—(I) the Geological Survey Report of Progress, 1858, pp. 61-63; (II) the Geology of Canada, 1863, pp. 724-729; (III) "Copper Mining in Canada East," by Herbert Williams, M.E., Transactions of the Literary and Historical Society of Quebec, 1864-65, pp. 41-46; (IV) "Notes on the Copper Deposits at Harvey Hill," by James Douglas, Jr., Transactions of the Literary and Historical Society of Quebec, 1870-71, pp. 42-52; (V) "Report on the Mineral Resources of the Province of Quebec," by R. W. Ells, Geol. Surv. of Canada, Vol. IV, 1888-89, pp. 42K–45K; (VI) Reports on the Property of the Harvey Hill Mining and Smelting Co.—published in Boston, June 1st, 1863; (VII) "Early Copper Mining in the Province of Quebec," by James Douglas, LL.D., Journal of the Canadian Mining Institute, Vol. XIII, 1910, p. 254-268.

The Harvey Hill mine is situated about seven or eight miles westward from Leeds station on the Quebec Central Railway. Rich copper ores were discovered about the year 1850. In 1853, the well-known mining and metallurgical expert, the late John Arthur Phillips, was sent from England by the firm of John Taylor & Sons to report on the Harvey Hill prospect. In 1856, the Quebec and St. Francis Mining Company was formed to purchase and work the property. In 1858 the English and Canadian Mining Company was organized with a capital of £40,000 to operate the mine on a more elaborate scale. Each successive report of the English Company combined regrets for the past with promises of a successful future.

From 1858 to 1864 the following quantities of ore were shipped from the mine:—

	Tons.	*Cwt.*	*Qrs.*	*Lbs.*	
1858	9	15	0	2	Averaging about 30 per cent.
1859	43	7	0	21	
1860	104	5	3	0	
1861	70	4	1	6	
1862	94	17	2	21	
1863	113	20	3	14	do. 26 do.
1864	235	12	3	3	do. 20 do.
Total	671	20	2	11	

The mining ton in the above table is 21 cwt, or 2,352 lbs. The decrease in the quality of the ore during 1863 and 1864 was attributed to the fact that smaller quantities of ore were taken from the quartz veins and more from the cupriferous bands of schist.

Because the original capital of the Company had been all called up, at an Extraordinary General Meeting held on Feb. 28th, 1861, the Directors of the English and Canadian Mining Company were empowered "to raise on mortgage the sum of 8,000 pounds to be taken up as the necessities of the Company might require." The report for 1862 brought the discouraging news that 5,000 pounds of this money had been spent and that no dividend could be forthcoming, "although the indications of mineral wealth still continue to be of a very encouraging nature." A fire at the ore-dressing plant interfered with the shipments. The Company sent out from England a Mr. A. Tregoning, who in his report stated that "the undertaking is one of considerable merit and is worthy of vigorous prosecution, aided by an adequate capital."

Exclusive of the original price paid for the mine and of large amounts for surveys and other preliminary expenses, the following items show the monies expended by the Company in the development of the property to December 31st, 1862.

	£	s.	d.
Cash expended in Buildings	1879	3	10
Salaries	3081	7	8
Other office expenses	365	8	6
Labor cost	17,468	12	1
Steam engine, apparatus, utensils	1070	1	4
Oxen, horses, hammers, carts	124	10	5
Metal, fuel, powder, etc	503	3	4
Total	24,492	7	2

In the report of the Directors at the Fifth Annual General Meeting on April 30th, 1863, it was made plain that "the funds at the disposal of your Directors being so nearly exhausted, it has been their study to suspend as far as possible all works not tending to immediate profit." The interesting statement was also made that the net proceeds of sales at Liverpool and Swansea of ores shipped in 1862 amounted to £2835 9s. 2d.

"The Englishmen being unwilling to risk more in the venture, some Canadians undertook to pay the Company's debts and buy out the English shareholders. The Canadian Company never had adequate means for prosecuting the work. The old dressing floor had been planned after the oldest English models, using hand jigs, and disregarding all labour-saving appliances. The water supply was inadequate and variable, being derived from hillside reservoirs. When the English Company was bought out, it was contemplated to build better works on the Palmer river not more than a mile away; but this reasonable plan was abandoned in favour of the leaching method of Messrs Whelply and Storer. It was a method based on sound chemical principles, but carried out by the adoption of as many mechanical complications as perverse human ingenuity could devise to frustrate success. Pulverized charcoal was added to the ore to create an intense heat in a shaft furnace where a most moderate heat was required. Storing pulverized charcoal in a room lined with canton flannel is as dangerous as storing lighted matches; and the mill, when it mysteriously caught fire, exploded, rather than burned up, before the process had really had a fair trial."* This disaster, involving an estimated loss of £20,000, occurred in 1866.

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*"Early Copper Mining in the Province of Quebec," by Dr. James Douglas, Jour. Can. Min. Instit., Vol. XIII, 1910, p. 264.

The figures for the output for 1865 do not appear to be available. For a part of 1866, 265 fathoms of ore were taken from the bed, dressed to 24 per cent and sold in Liverpool for $35,240 at an average of fifteen shillings per unit.

Owing to the fire, operations apparently were suspended until 1869 or 1870, when Dr. James Douglas, Sr., took a lease of the property, undertaking to pay $5,000 a year and to erect a 50-ton concentrating mill. Concerning this venture, Dr. James Douglas, Jr., writes:—"His operations under the lease were less unsuccessful than they had been under the old company. The output rose to about 500 tons of concentrates a year and the revenue nearly covered the actual operating expenses. It was, however, a struggle against penury; and while extravagance has wrecked many a mining enterprise, to the shifts and uneconomical expedients, incident to shortness of funds, not a few other failures have been due."

The property promised so well that in 1872 the Consolidated Copper Company of Canada was organized in Glasgow, Scotland, to provide a working capital. With the belief that the veins would be continuous and maintain their copper values, Captain Whitburn, the managing superintendent, decided to sink a shaft nearly 2,000 feet distant on the strike from the point the veins had been explored. "The veins were found where expected, but they were barren, and the Company treasury was empty. The Company was wound up in 1879." Dr. Douglas adds:—"The same series of events have, I believe, been repeated since then—resuscitation, a lingering life, death, and burial. And yet I think the property may deserve a better fate."

It should be pointed out that the early mining operations on this property were much inconvenienced by inadequate transportation facilities. The ore and concentrates were taken by team to Methot's station on the Grand Trunk railway, a distance of 21 miles. In 1865,* Mr. Herbert Williams stated that:—"We have paid as high as $10 per ton for the carriage of our ores to Quebec; we now pay $7.00." In 1879, when work on the property was suspended, the Quebec Central railway, building from Sherbrooke, had reached Coleraine station, and was opened throughout in June, 1881.

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*Before the waggon road to Methot's station was built, the ore was taken by team to Craig's Road station, a distance of 31 miles.

In 1882, three men employed by a New York Company are said to have spent more than ten months in removing the water from the Kent shaft by means of a hand windlass. In 1888, the mine was reopened by the Excelsior Copper Co., of London, England. It is claimed that in four months and a half 520 tons of 20 to 50 per cent ore, and 270 tons of 6 to 25 per cent ore were shipped to England. About 400 tons of ore, containing about five per cent of copper, were taken from the mine, and with the intention of smelting ore of this lower grade, a crushing and concentrating plant was erected and a small blast furnace was installed. Coke for the blast furnace was brought from Nova Scotia, limestone from Dudswell, Quebec, and magnetite from McVeity's mine, near Kinnear's Mills, Quebec. The venture was not financially successful. In the year ending June 30th, 1890, it is reported that 40 tons of 30 per cent, 60 tons of 17 per cent and 100 tons of 14 per cent copper ore were taken from the mine. In 1891, the Company was reorganized as the Leeds Copper Company of London, England, but their operations ceased in 1892.

In September, 1895, the property passed into the possession of the Copperfield Mining and Milling Company, in which the late Dr. James Reed seems to have held the controlling interest. This Company worked the property on a very small scale until 1899, when the mine was closed and has remained idle ever since. In 1896 and 1897, forty tons of rich and of concentrated ore, carrying about 20 per cent of copper, were sent to market. In 1898, no ore was shipped, but in 1899, small shipments carrying about 19 per cent of copper were made. In 1903, two tons of selected ore were sent to the St. Louis Exhibition.

The workings are situated towards the summit and on the northwestern slope of a hill composed of slaty schists that strike N.E. to S.W. and usually dip from 10 to 20 degrees toward the northwest. Varying from very light to dark gray in colour, some bands of these schists are very rich in chloritoid or ottrelite. Veins composed of quartz, calcite, and dolomite (in which a small portion of the magnesium is replaced by iron), traverse the schists, usually striking N. 15° E. to N. 35° E. Some of these veins carried bornite, chalcopyrite and often, in less amount, some chalcocite. In a few of the veins a little molybdenite was present. One of these veins, known as the Fanny Eliza lode, which yielded some very rich copper ore, was encountered in the Kent shaft. When first met with, near the shaft, it was only a few inches in width but widened as work progressed upon it. In December, 1870, Dr. Douglas, Jr., described it as follows:—"The lode is from 20 inches to 24 inches in width and very regular in both strike and dip, which is slightly to the west. The ore as it comes to the surface yields from 8 to 12 per cent of copper. It separates in crushing very perfectly from the gangue and is, therefore, easily concentrated to from 40 to 50 per cent. It consists of a mixture of gray and purple sulphurets. When the lode enters the bed it carries a good deal of yellow and no gray ore, but the yellow entirely disappears in depth...... There can be hardly a doubt that the Fanny Eliza is a true lode. It has not varied in direction or width for forty fathoms; its dip is as regular as its strike and, at places, distinct friction-surfaces have been observed."

Three bands or "beds" of the slaty schists were found to carry disseminated grains and small intercalated stringers of chalcopyrite, often with some bornite and pyrite. According to Dr. Douglas: "If these beds extend over the entire hill, they would exist at the following depths below the surface at Kent's shaft:—(*i*) The uppermost bed, cut in Grass shaft No. 2, and from which a great deal of ore has been extracted by the Kent shaft at 20 fathoms from the surface. (*ii*) The second bed, that lying on the soapstone in Fremont's shaft, which should be at about 60 fathoms from the surface; and (*iii*) the lowermost bed, that met with near the end of the adit, and which should be at about 20 fathoms deeper still, or at 80 fathoms from the surface. There is, however, no likelihood of these beds being of such great extent, and it is certain that they are not of the uniform thickness at one time attributed to them."*

The geologists, who examined the property during the early days of working, considered that these mineralized bands of slaty schists were true bedded deposits and that the copper minerals had been deposited from the waters of the ancient sea within which the sediments accumulated that were consolidated to form the slates. They also believed that the copper minerals in the veins had been derived from the beds. It was in 1870, from observations he had made during the working of the uppermost bed, that Dr. Douglas pointed out that these mineralized "beds" were very variable in width, that they lacked continuity, and that their copper content was very irregularly distributed, being higher where intersected by the cupriferous quartz veins. He expressed the belief that "the deeper beds fed the upper bed" and concluded that "strictly speaking, therefore, these cupriferous slates do not belong to beds at all but should be classed as impregnations." The uppermost bed is said to have usually varied from 2 to 10 feet or more in thickness. The second bed is said to have comprised three inches of cupriferous slate followed by fifteen feet of barren slate, beneath which six inches in thickness of the slate also contained values in copper. The thickness of the third bed is not given in literature, but it is described as having been encountered about 120 feet from the extreme end of Morrison's adit, where "a light gray slate was met with carrying a little copper pyrites and a considerable amount of chloritoid, and the same kind of ground is now in the end. This last band is irregular in its dip, which is in some places 35 degrees and 40 degrees, and in others 10 degrees to 14 degrees."[1]

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*Early Copper Mining in Quebec, by James Douglas, LL.D. Journal Canadian Mining Institute, Vol. XIII, 1910, pp. 265-266.

In the early days (prior to 1863) of working, at a point about 200 feet below the summit of the hill, an adit was driven into the hill for 1488 feet. In addition to several trenches and smaller pits, eleven or twelve shafts have been sunk, each to a depth of 40 feet or more. Those shafts, known as the Harvey Hill, the Freemont, Grass shaft No. 2, the Douglas, the Kent, the Sayles and the Whitburn, are said to equal or exceed 100 feet in depth. Both the McGee and the Poulin shafts are said to be about 40 feet deep. The Kent shaft, from 900 to 1,000 feet westward of the adit, descends 180 feet vertically; a cross-cut was then extended for 100 feet or more to the westward and an incline sunk to a depth of about 600 feet. Not far removed from the Kent shaft is another (2) which descends vertically for 210 feet. The underground workings connected with some of these shafts are said to be extensive.

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[1] Report on the Property of the Harvey Hill Mining and Smelting Co., April, 1863.

(2) I think that this is known as the Sayles shaft.

Circumstances did not permit the writer to spend more than one day upon this property. Some important geological problems presented themselves which would demand more time in detailed study, both in the field and the laboratory, than the writer has had at his disposal. An important question to be considered is—To what extent has secondary sulphide enrichment taken place, both in the veins and in the irregularly impregnated bands of schist? In at least some of the veins, the calcite and dolomite are later than the quartz, and with these carbonates, the boruite appears to be closely associated.

From information gathered, the writer is convinced that all of the rich ore that was in sight has been removed from the mine, and that the uppermost mineralized band of schist has been quite extensively worked. The presence of ore, much of which may be low in grade, would have to be demonstrated by further exploratory work before anyone would be justified in regarding the property as a source from which ore can be shipped profitably.

The following quotation from Dr. Douglas's* paper outlines the course that should be pursued by those who may contemplate reopening the mine:—"No exploratory work was done and no ore was extracted from any of the beds but the uppermost; and as the deeper beds were not encountered in sinking on the chutes of ore in the Fanny Eliza vein, they probably are not of very great extent. The areas of these beds and their copper contents could, however, be very cheaply determined by either churn or diamond drills. Should any intention to reopen the mines be seriously contemplated, such preliminary exploration should be done on the beds, as the contribution of ore from the veins, though valuable, would probably be small, and the beds would have to be looked to for quantity."

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*"Early Copper Mining in Quebec," by Dr. James Douglas, Journ. Can. Min. Inst., Vol. XIII, 1910, p. 266.

CHAPTER VII.

COPPER DEPOSITS BETWEEN THE SUTTON AND ASCOT BELTS.

POTTON TOWNSHIP:

From the Lake Memphremagog mine on lot 28, range IX, of this township, 800 tons of pyrrhotite carrying a low percentage of copper has been shipped.

The Lake Memphremagog Mine—(known also as Smith's Mine or the Potton Mine) range IX, lot 28, Potton. "The new mine of the Memphremagog Mining Company, lot 28, range IX, Potton, was examined. It shows a body of ore, mostly iron and copper pyrites, about sixteen feet thick, and extending several hundred yards. This is capped by a considerable body of bog-iron ore which should be valuable if facilities for shipping and smelting were afforded. But little work other than exploratory has yet been done at this place." (R. W. Ells in G.S.C., Vol. IV, 1888-89, p. 34A; also repeated on p. 30S, and again on p. 48S.)

"In no case yet observed in Potton township is the quantity of ore sufficient to warrant any great outlay in exploration except possibly at the recently discovered mine on lot 28, range IX, on the west side of the Hog's Back Mountain, owned by the Memphremagog Mining Co. This mountain is a mass of diorite rising to a height of 800 feet above Lake Memphremagog, and surrounded on both sides by black and bluish grey slates. The deposit of ore, which is principally a pyrrhotite with a small quantity of copper pyrites, occurs on the west side, at the contact of the diorites and slates, in a bed 15 to 18 feet thick, which extends along the side of the mountain for several hundred yards. It dips northwest at an angle of about forty degrees, having the diorite for its foot wall, and the surface above the vein and for some distance beyond is covered with a heavy bed of bog-iron ore. The ore in places contains a considerable quantity of a dark-coloured or almost black calcite. On this vein, several pits have been sunk at intervals along a distance of 1,000 feet, and according to the Manager, an inclined shaft has been put down on the vein for 85 feet. A cross-cut has also been driven with the vein so as to drain the pits. About 800 tons of the ore have been extracted and piled, waiting for shipment. From several assays by Dr. Wyatt of New York, and by Torrey and Eaton, the ore contains from different samples:—Iron 30 to 50 per cent, copper 2.80 to 5 per cent, sulphur 37.75 to 42 per cent. A peculiarity of this ore is the readiness with which it spontaneously ignites when piled in heaps exposed to the weather; a feature not common to the ores from most of the other localities.

"This mine is situated at 700 feet above the lake, connected by a good road of a mile length with landing stage, and good facilities for shipment either to Magog or Newport." (R. W. Ells in G.S.C., Vol. IV, 1888-89, p. 46K.)

"This mine is 3½ miles from South Bolton Station on the Orford Mountain Railway, and three-quarters of a mile from Lake Memphremagog for lake shipments. Considerable work has been done. It is estimated that there is in sight over 100,000 tons of ore. Copper from 3 to 5 per cent. Sulphur from 33 to 45 per cent." (Partial list of Copper and Sulphur Properties in the Eastern Townships from which Sufficient Ore has been guaranteed to meet capacity of Customs Smelter and Chemical Works at Sherbrooke, P.Q., by J. R. Woodward, of Sherbrooke (published in 1902).)

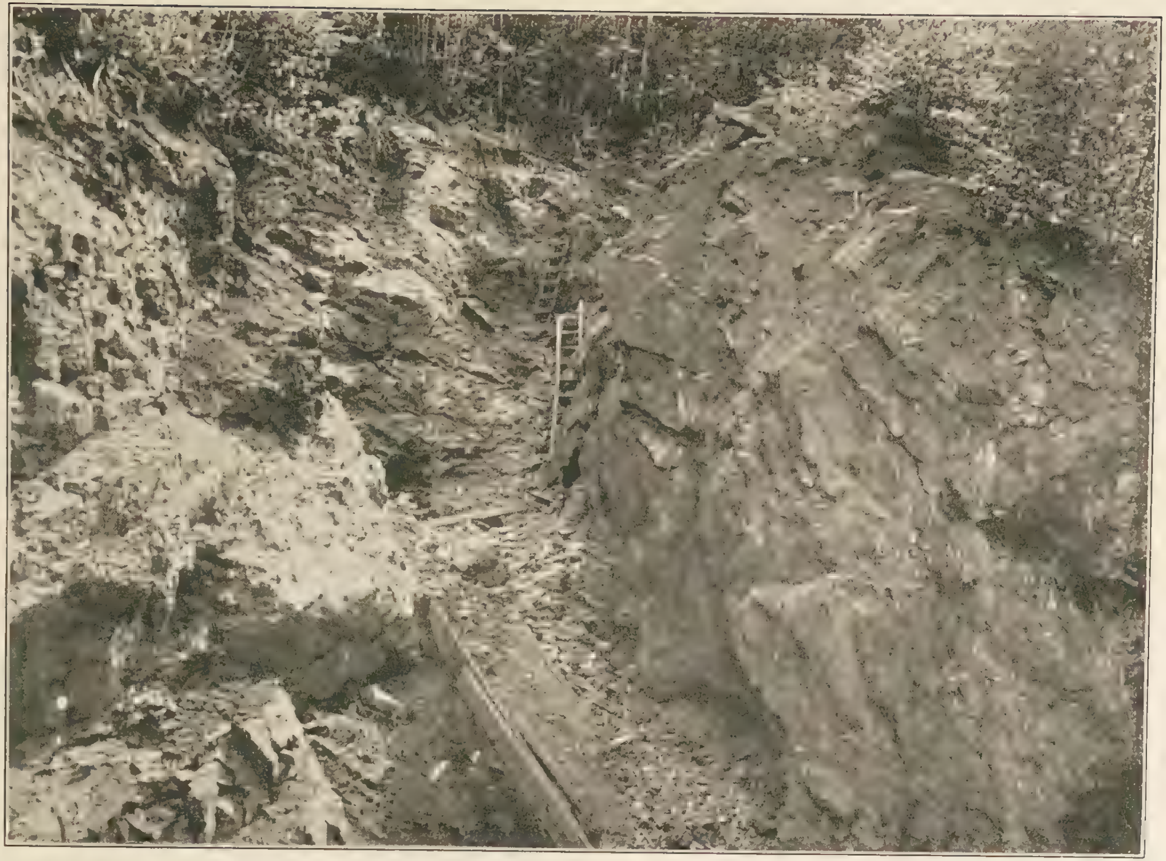
"The Lake Memphremagog Mining Company, after spending a considerable sum in development work, has closed down the mine at the Hog's Back Mountain for the present, owing apparently to a lack of profitable market for their ore. This is a pyrrhotite already described in G.S.C., Vol. IV, 1888-89, and no further details can here be given of this property." (R. W. Ells in G.S.C., Vol. VII, 1894, p. 88J.)

"Another occurrence of copper which is not related in position or geological relation to those already described is found on the west side of Lake Memphremagog, principally in the townships of Potton and Bolton. The largest of these, the property of Mr. G. E. Smith, is about two miles from Knowlton landing, but I was not able in the time available to ascertain the full extent of this occurrence. It has been developed by sinking a shaft some 80 feet in depth, while a horizontal tunnel, 100 feet in length, cross-cutting the ore body, reaches the shaft fifty feet from the surface. The course of the cross-cut is toward Sugar Loaf Mountain on the west side of which the mine is situated, and the ore body seems to be a phase of the zone of contact of an intrusive mass of the mountain with the surrounding sedimentary rocks. The ore is a pyrrhotite said to carry a small percentage of copper. It oxidizes very readily, giving a strong odor of sulphur in the shaft. The amount of sulphur, of which it is reported to contain 35 per cent, which is carried out in solution by water is surprisingly large. Drift material, fallen branches and leaves of trees are cemented together by the iron thus leached out. Several inches of this recent conglomerate are said to have been deposited since the uncovering of the ore body ten or twelve years ago." (J. A. Dresser in G.S.C., Vol. XV, 1902-03, pp. 315A-316A.)

"The townships of Botton and Potton, to the west of Lake Memphremagog, contain several igneous hills of the general type of Mt. Orford which are intrusive through lower palaeozoic sediments. Where these have cut black Trenton shales, large bodies of pyrrhotite and pyrites and allied ores have frequently been found. These are probably the largest ore bodies in the Eastern Townships. The Huntingdon mine, the Ives mine and the Lake Memphremagog mine are the best known. These large deposits are worth the most careful attention of those interested in copper mining." (J. A. Dresser in G.S.C., Vol. XV, 1902-03, p. 149A.)

"The Smith mine at Hog's Back Mountain has, since the report of 1888-89, been further developed by sinking a shaft about 80 feet deep, and by a horizontal tunnel 100 feet in length cross-cutting the ore body in the shaft at 50 feet from the surface. The ore carries from 1 to 7 per cent of copper with about 35 per cent of sulphur and a small percentage of nickel and is a pyrrhotite. A considerable body of bog ore forms a capping over the main ore body and this has been shipped to the furnaces at Drummondville for the manufacture of iron. There appears to be a very large body of the pyrrhotite at this place, but beyond development work to a limited extent, but little mining has recently been done. It occurs along the contact of the diorites of the Hog's Back and Sugar Loaf Mountains with the belt of black slates which traverse this district." (R. W. Ells in G.S.C., Bulletin on Copper, No. 882, 1904, p. 55.)

"The Lake Memphremagog mine is situated on the northwest slope of Hog's Back Mountain, two miles from Tuck's landing, in

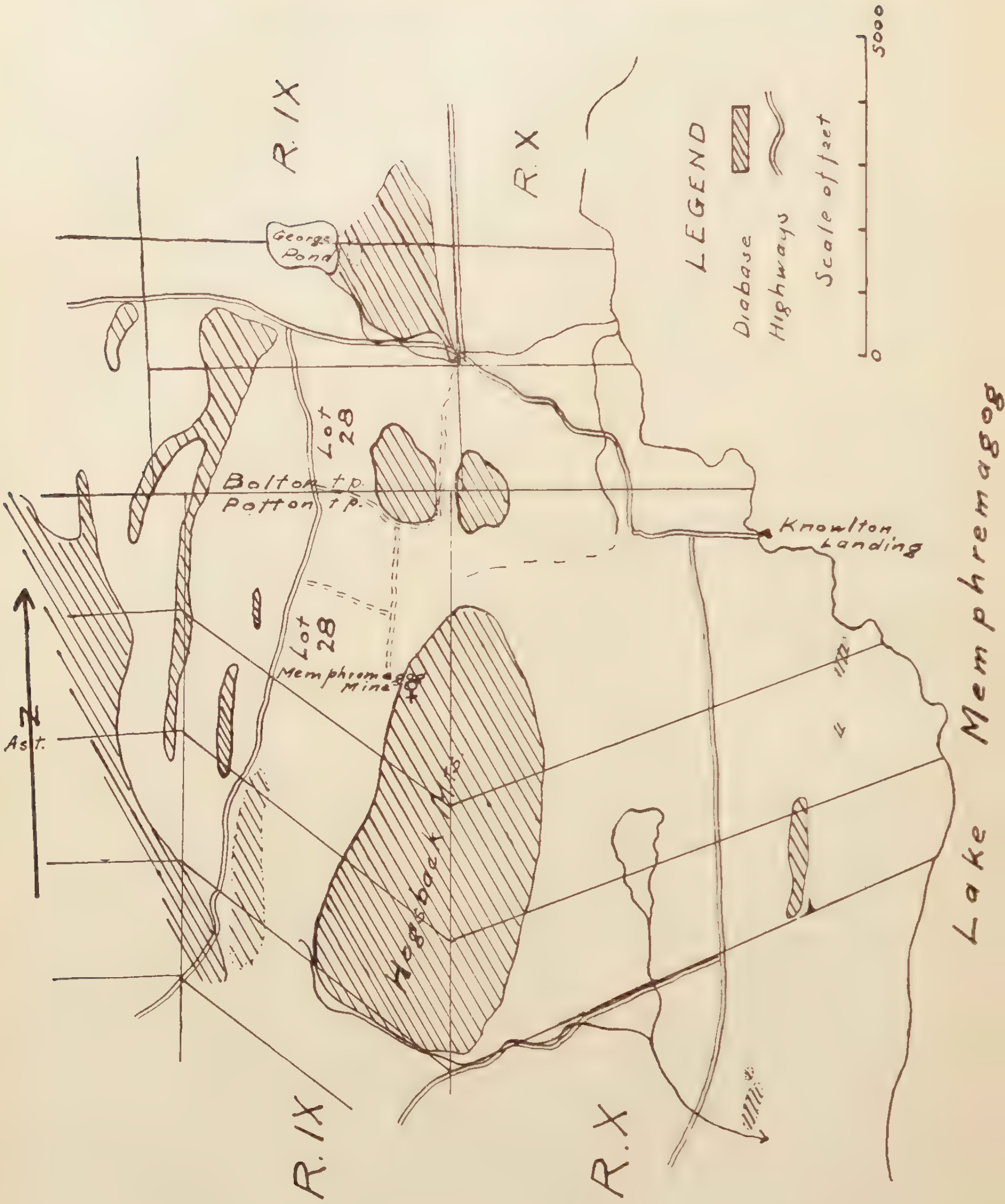


Open-cut of the Lake Memphremagog mine, Range IX, lot 28, Potton township.

the township of Potton. The development of this property consists at present of a vertical shaft, 80 feet in depth, with an adit driven in to meet the shaft at a depth of 50 feet from the surface. The ore-body extends in length for 300 feet in sight, and exposures a thousand feet apart are probably the continuation of the same deposit. In the adit, which is a cross-cut, 110 feet of ore are exposed without the inner limit of the ore body having been reached. This ore varies in the amount of copper it carries from one to nine per cent. There are also small amounts of gold, generally enough to be appreciable." ("Report on the Copper Deposits of the Eastern Townships of Quebec" by J. A. Dresser, G.S.C., 1907, p. 15.)

"At the Memphremagog mine about two miles from Knowlton Landing on Lake Memphremagog, a new shaft was sunk about 150 feet north of the old shaft. At the time the mine was visited (July) this shaft had passed through the ore and was being sunk in the county rock near the contact between the diabase with which this ore is associated and the schists. The old shaft had also been unwatered and was being deepened. The ore is pyrrhotite, containing a very small amount of chalcopyrite, which usually appears as thin films along fracture planes. Near the south shaft, the ore body has an extreme width of about 20 feet and a length probably of about 200 feet, the average width being about 12 feet. In the opinion of the writer, the total amount of ore, as shown by the workings at the time the mine was visited, will not be more than 20,000 tons; the copper content is very low, probably less than 2 per cent. Disseminated pyrite had been found in a number of pits and trenches to the north along the line of contact between the diabase and the schists, but no new ore bodies of commercial value had been discovered at the date when the mine was visited." (A. W. G. Wilson, in Summary Report of Mines Branch, Ottawa, 1909, pp. 70-71.)

"This is situated on the north-west slope of Hog's Back Mountain' not far from Knowlton Landing. According to the estimate of Dr. A. W. G. Wilson, of the Mines Branch, the amount of ore as shown by the present workings will not be more than 20,000 tons, with a copper content of less than 2 per cent. A quantity of ore, reported to be as much as 500 tons, shipped in 1907, is the total production to date." (R. Harvie in Summary Report G.S.C., 1911, page 287.)


R. IX
R. X
George Pond
LEGEND
Diabase
Highways
Scale of feet
0
5000
Lot 28
Bolton tp.
Potton tp.
Knowlton Landing
Lot 28
Memphremagog Mine
Hogsback Mt.
N
Ast.
Lake Memphremagog
R. IX
R. X

This mine is situated on the western slope and toward the northern end of Hogs Back mountain on the west side of Lake Memphremagog. An intrusive body of diabase forms the main mass of this mountain, while the ore-body, consisting of massive pyrrhotite with a very little chalcopyrite, lies at the contact between the diabase and clay slates of lower Palaeozoic (probably Ordovician) age. The outline of this intrusion of diabase and also of others in adjacent portions of Potton and Bolton are depicted in the accompanying sketch map prepared by Dr. R. Harvie of the Geological Survey of Canada, Ottawa. About two miles from Knowlton Landing on Lake Memphremagog, the mine is said to be approximately 700 feet above the level of the lake. To South Bolton, the nearest station on the Orford Mountain Railway, the distance is about four miles.

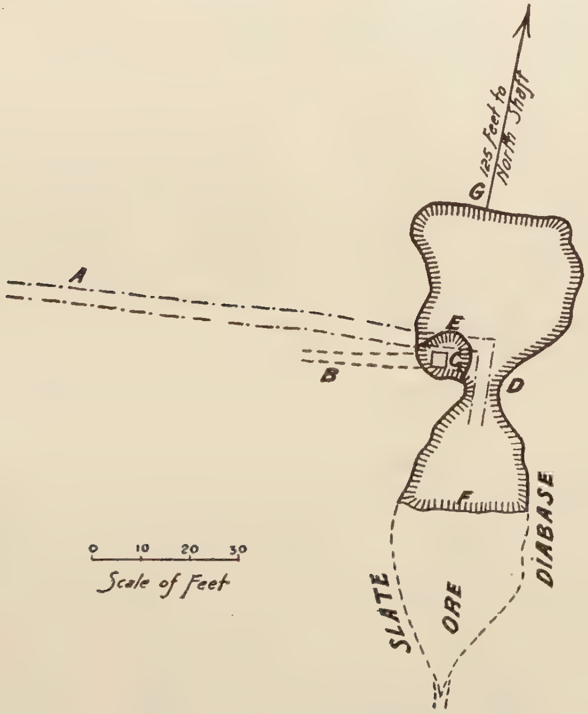


Fig. 4.—Plan of workings at the Lake Memphremagog mine.

A considerable portion of the ore body has been exposed by an open cut 65 feet in length, 35 feet in maximum width and about 20 feet in maximum depth. Stripping to bed rock has shown that the body of ore tapers to a point 32 feet southward from the open cut. From this point, if the ore body is followed northward, it is found that within 30 feet, it attains a width of about 20 feet (the vertical wall of ore in the inner portion of the open cut as shown in Plate V, and at F in the accompanying sketch Fig. 4); within the next 28 feet, it narrows to a width of six feet (the constriction in the open cut, shown in Plate V, and at D in the sketch); for about 40 feet farther, it possesses an average width of about 12 feet when it passes beneath the soil covering (at G in sketch). The body of ore dips from 35° to 50° toward the N.N.W. From short distances down the slope of the hill, two tunnels have been driven toward the open cut. One of these (B in the sketch) is of no importance, and with a length of about 30 feet traverses slates at a depth of 4 or 5 feet below the surface. The other tunnel (A in sketch) penetrates approximately 125 feet through slates, and passes into ore beneath the open cut. The roofs of the outer portions of both of these tunnels have collapsed but access may be gained to tunnel A by descending through an opening 10 or 12 feet in depth in the open cut (at E in sketch). From here the tunnel extends about 20 feet to the east beneath the open cut and then turns for 22 feet toward the south; these portions of the tunnel are in solid ore. Immediately south of the tunnel, at the point where one descends into it from the open cut, an inclined shaft (C in sketch) has been sunk to a depth of about 80 feet, and, near the bottom, it is said to have encountered a slip and passed from ore into rock.

About 125 feet northward from the above open cut, a shaft, inclined quite steeply westward, has been sunk at the contact between the diabase and the slates. Reported to have a depth of 90 feet, this shaft also passed through similar ore into rock; the large dump of rock at the mouth of this shaft bears testimony to the amount of barren ground that was penetrated. Apparently it has not yet been definitely demonstrated that the ore encountered within this shaft is continuous with that exposed in the open cut. Within three hundred yards northward along the contact from this shaft, considerable trenching and stripping has been done and a few small pits sunk. Although portions of the rock have been found to be impregnated with scattered grains of pyrrhotite, pyrite and chalcopyrite, nothing of economic value has been discovered by this work. The ore from this property is a massive pyrrhotite containing very small amounts of copper pyrites and occasionally a few grains of black zinc blende. Frequently, the ore is traversed by minute veinlets of black calcite, introduced by solutions following minute fractures that apparently developed, by crushing movements, subsequent to the formation of the ore-body. In general, the small grains of zinc blende are of rare occurrence, being more abundant within the marginal portions of the deposit, where a few scattered grains of chalcopyrite are also present. Study of a specimen of ore taken from the inner or eastern margin of the deposit shows that the zinc blende was deposited first, then the pyrrhotite and lastly the chalcopyrite.

The chalcopyrite was deposited subsequent to the development, through the action of pressure, of small cracks in the earlier minerals, and hence as a rule it appears as thin films upon minute fracture planes. The bog iron ore, or limonite, formerly present as a gossan, has been almost completely removed; on the eastern margin of the inner portion of the open cut, a few square feet of the surface of the ore-body are covered to a depth of nine or ten feet with limonite.

Where adjacent to the diabase, the clay slates have been altered to a compact light grey hornstone, which is frequently more or less impregnated with the sulphides already mentioned. When examined in thin section under the microscope, a specimen of the diabase, at immediate contact with the ore-body, was found to be so altered that of its primary minerals, it retains only a small amount of feldspar, the remaining portion of the rock having been converted into sericite, chlorite, calcite and quartz, and partially replaced by small grains of pyrrhotite, zinc blende and chalcopyrite. The ore-body appears to have been developed by the replacement of the more altered clay slates, and possibly of a minor portion of the marginal phase of the diabase.

A composite sample of small specimens taken at intervals of about a foot across the exposed width of ore in the inner portion of the open cut (at F in sketch) yielded an assay—Copper 0.32

per cent.* A few cracks extend downward for a few feet from the surface into the ore, and the passage of surface waters has converted the adjacent ore into irregular seams of a black powder, sometimes two or three inches in width.

An assay for copper of a specimen of this material showed the presence of 0.84 per cent of this metal. I was informed that the ore in the shaft within the tunnel would yield, according to assay, about 2 per cent of copper. To the present time, 800 tons of ore have been shipped from this property, 500 tons in 1907 and 300 tons prior to that year.

It should be observed that it is impossible to find any corroboration of certain statements in some of the previous reports, as for example that "the deposit of ore, in a bed 15 to 18 feet thick, extends along the side of the mountain for several hundred yards." In the open cut an ore body, terminated toward the south, is exposed for a length of about 100 feet; about 125 feet north of the open cut, a shaft passed through similar ore; prospecting work north of this shaft revealed nothing of value. Although specimens may be selected or small quantities of ore may be assembled with difficulty that will carry three to five per cent of copper, it is certain that the average copper content is certainly less than two and probably less than one per cent.

Bolton Township.

Libby's Mine, Range VII, Lot 24, Bolton.—"Prospect pits, on lots 24 and 25 of range VII, Bolton, sunk recently, do not show any valuable ore bodies." (R. Harvie in Summary Rept. G.S.C., 1911, p. 291.)

In the summer of 1910 and in the autumn of 1912, work was done on this property by Mr. Leander Libby of Bolton Centre. At a distance of about eighty rods east of the Orford Mountain Railway, a shaft, 9 ft. x 11 ft. has been sunk to a depth of 22 feet, and, at the bottom, a drift extends for five or six feet to the northwest. The shaft penetrates a sheared zone in a very large dyke-like intrusion of diabase that strikes slightly east of north. A few feet to the west of this shaft, the western margin of the diabase is in contact with slates. In the vicinity, the diabase usually displays a marked tendency to schistosity. Within the shaft for a width of about four feet, it is altered to chlorite schists striking about N. 30° E. with a vertical dip.

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*Note.—A complete analysis of a specimen of the ore (published in Mr. Obalski's report for 1889-90) is as follows:—Copper, 4.70%; Zinc, 2.30%; Lead, 0.30%; Antimony, 1.65%; Nickel-traces; Silver, a trace; Arsenic, a trace; Sulphur, 36.50%; Iron, 43.70%; Lime and Alumina, 5.70%; Silica, 5.00%; Moisture, 0.15%.

Within this more schistose band, two or three small veinlets of quartz, up to three inches in width, carry pyrite and an occasional grain of chalcopyrite. A few crystals of pyrite, up to three-fourths of an inch across, as well as some small grains of chalcopyrite, are widely scattered within the chlorite schists. Indications do not warrant the renewing of prospecting operations in the vicinity of this shaft.

Range VII, Lot 25, Bolton.—"Yellow sulphuret disseminated to a breadth of four feet in green chlorite slate." (G.S.C. 1866, p. 299.)

Although not mentioned by Ells in his reports, a symbol indicating the presence of copper upon this lot appears upon the geological map (the Montreal sheet) accompanying G.S.C. Part J, Vol. VII, 1894.

"Prospecting pits, on lots 24 and 25 of range VII, Bolton, sunk recently, do not show any valuable ore bodies." (R. Harvie in Summary Rept. G.S.C. 1911, p. 291.)

Recently some work has been done on this property by A. O. Norton of Coaticook and G. Smith of Montreal. Between one and two hundred yards east of the Orford Mountain Railway, on the farm of Kelvin Davis, a shaft, 10ft by 6 ft, was sunk to a depth of 17 or 18 feet in chlorite schists, the metamorphic equivalent of diabase. Somewhat more schistose than the rock at Libby's shaft on lot 24, it is a portion of the same large dyke-like intrusion of diabase, the western contact of which here lies about forty or fifty yards to the westward. A trench, six to eight feet in depth, extends 12 feet toward the southeast. Considerable stripping of the bed rock has also been done.

At the time of my visit there was less than two feet of water in the shaft. The chlorite schists strike N. 33° E. with a vertical dip.

Narrow irregular bands of the schist have been impregnated with quartz and scattered grains of chalcopyrite. Occasionally, the chalcopyrite appears as minute veinlets, up to a few inches in length, that are interleaved with the schists. These more schistose bands are traversed parallel to their schistosity by narrow quartz veins carrying a few scattered grains of chalcopyrite. Usually only a few inches in width, these mineralized streaks appear rusty on weathered surfaces. Within a width of thirty feet, transverse to the schistosity, six of these bands are present. If any of them be followed in the direction of strike, they are found to, within a few feet, vary from a few inches to an exceptional maximum of two or three feet in width; within a few feet or yards they die out, and further along the strike other similar bands may or may not appear. The copper content of these mineralized streaks is low, and even if much richer in copper, they are not close enough together to suggest the possibility of a successful mining enterprise.

Holland Mine, Range VII, Lot 26, Bolton.—Yellow sulphuret and green carbonate in chloritic slate. A trial shaft has been sunk to a depth of from 25 to 30 feet on a bed of eighteen inches, in which the ore is sparingly disseminated. Ives and others hold the mining rights." (G.S.C. 1866, p. 300.)

Although not mentioned by Ells in his reports, a symbol indicating the presence of copper upon this lot appears upon the geological map (The Montreal sheet) accompanying G.S.C., Part J, Vol. VII, 1894.

About fifty years ago, prior to the discovery of what is now known as the Ives Mine at Eastman, this property was worked by the Ives brothers. They then sank a vertical shaft to a depth of 25 feet. A few years ago Messrs. W.A. Cromwell and N. Parker, of Eastman, extended this shaft, which is about nine feet square at the surface, to a depth of 60 feet. It is near the foot of the western slope of a low ridge, less than a 100 yards to the east of the Orford Mountain Railway (now a branch line of the C.P.R.) To facilitate the handling of the rock, a trench, with a maximum depth of eight feet, extends from the shaft toward the west for 50 feet.

The shaft is situated at the western margin of the very large dyke-like body of intrusive diabase, mentioned in the description of the two preceding properties, that strikes in an approximately north to south direction and is here in contact with slates. The diabase has been sheared into chlorite schists, striking N. 34° E. and dipping 85° to the southeast. Narrow bands, along which the schistosity is more intense, are impregnated with disseminated grains of chalcopyrite and pyrite. Upon weathered surfaces, these bands appear as rusty streaks which usually are only a few inches and do not exceed from two to three feet in width. Within a few feet along the strike, they narrow from a maximum to a minimum width, or they die out. Narrow quartz veins, up to three or four inches in width, and carrying scattered grains of chalcopyrite, traverse these more schistose bands, parallel to their schistosity. Although some rather good specimens of copper ore may be collected, the average copper content of these mineralized streaks is low and surface indications show that they are too irregular in width and are not close enough together to constitute a serious mining proposition. Mr. Cromwell informed me that this conclusion was corroborated by work in the shaft.

Range VII, Lot 27, Bolton.—"Yellow sulphuret in light green talcoid slate near serpentine." (G.S.C. 1866, p. 300.)

Although not mentioned by Ells in his reports, a symbol indicating the presence of copper in this lot appears upon the geological map (The Montreal Sheet) accompanying G.S.C. Part J, Vol. VII, 1894.

The western marginal portion of the same large dyke-like intrusion of diabase, as that on lots 24, 25 and 26 of this range, is exposed in a cutting of the Orford Mountain Railway, about 200 yards northward from South Bolton Station. Narrow, irregular bands of the schistose diabase, similar in character to those described upon the three preceding properties, carry a very few small scattered grains of pyrite and chalcopyrite. About fifty years ago a shaft was sunk to a depth, now reputed to have been 20 to 25 feet, and less than a 100 yards north of the shaft, a tunnel was driven eastward into the hill. To-day the shaft is situated a few yards to the eastward of the railroad, during the construction of which, the tunnel, which is said to have been 25 feet in length, was destroyed.

The Ferrier Shaft—Range VIII, Lot 4, Bolton.—To-day, the name Ives mine refers to the workings on lot 2, range IX, but in 1866 to 1875, the then Ives Mining Company controlled "the west half of lots 2, 3 and 4 in the 9th range and part of lots 3 and 4 in the 8th range of the township of Bolton, comprising about 400 acres. It was in 1866 that, upon the eastern portion of lot 4, range VIII, and about sixty yards east of the road from Eastman to South Bolton, the first shaft was sunk. In his report on the Ives mine in 1869, the late Professor E. J. Chapman, of Toronto, writes:—"The first shaft was put down on the 8th range to a depth of about seven or eight fathoms. This is known as the Ferrier shaft. The sinking at this spot was subsequently stopped and workings were opened about two-thirds of a mile farther north, on lot 2 of the 9th range." In estimating the amount of ore "on the ground at the time of his visit (June 10th, 1869) he states that:—"A small parcel of dressed ore, about four and a half tons of twelve or twelve and a half per cent, and another of nine tons of undressed of three per cent ore or thereabouts, lie at the Ferrier shaft."

In a report on the property of the Ives Mining Company in 1872 by the late Mr. C. H. Robb, there appears the statement that the first shaft, which has been called the "Ferrier Shaft," was sunk to the depth of ten fathoms on lot 4 in the 8th range; and levels or cross-cuts were driven east about four fathoms and west five fathoms. These works, while amply confirming the metalliferous nature of the rocks and their identity with those of the Huntingdon mine, did not at that depth yield as much ore as was expected (in all about four tons of ten per cent ore), and were accordingly in the meantime suspended, while new workings on a more extensive scale were opened at a more promising point about half a mile farther north on lot 2 in the 9th range.

At the Ferrier Shaft, chlorite schists are traversed, parallel to their schistosity, by a considerable number of narrow irregular quartz veins, none of which exceed six inches in width. Some of these veins send forth reticulating veinlets. The schists strike about N. 30° E. and dip 85° to the southeast. Portions of some of the quartz veins carry a little pyrite and chalcopyrite. Narrow bands of the schists adjacent to the veins are impregnated with scattered grains of these sulphides. To-day, the workings appear as a large opening, 27 feet along the strike, about 14 feet wide and now about 20 feet deep, with the bottom covered with loose rock. About 40 feet northward from this opening is a shaft so filled up or caved that it is now only 5 or 6 feet in depth.

Neither the surface indications nor the old reports quoted above offer much encouragement to those who may desire to continue work at this point.

The Canfield, Bolton, or Canadian Mine—Range VIII, Lot 6, Bolton.—"Yellow and variegated sulphurets with small masses of native copper disseminated in a width of five feet of chloritic slate, with serpentine on the west side. A shaft of forty feet has been sunk. The mining right is held by the Ives Mining Company; the land belongs to J. Canfield." (G.S.C., 1866, p. 300.)

Under the name of the *Canfield* mine this property is merely mentioned in the reports prepared in 1872 on the Ives mine by Chas. Robb and Dr. T. Sterry Hunt.

"North of the Huntingdon mine on lot 6, range 8, were the works of the Canadian mine, presumably on an extension of the vein just described. Two shafts were here sunk, one to a depth of 100 feet, the other 50 feet, and some ore shipped to Capelton. The mine subsequently passed into the hands of the Eastern Townships Bank and has not been worked for some years." (R. W. Ells in G.S.C., Vol. IV, 1888-89, p. 48K; also in G.S.C. Bulletin on copper, 1904, page 43.)

Locally this property is known under the name of the Canfield or Bolton mine rather than as the Canadian mine. The mining work was done at the western margin of a long dyke-like intrusion of diabase, about 250 feet in width. At the foot of a bluff about eighty yards to the east of the road leading from Eastman to the Huntingdon mine, and just a few yards south of the first junction of this road with one coming from the westward, two dilapidated vertical shafts are now full of water. These shafts are but a few yards apart and on a line corresponding to the strike of the regional schistosity, viz., about N. 35° E.

An examination of the dumps and adjacent exposures suggests that here the mineralization of a shear zone, a few feet in width, had proved to be too irregular to be remunerative. The rock is similar to that at the Ives mine, and along the shear zone it has been more or less impregnated with disseminated grains of pyrite associated with a little pyrrhotite and chalcopyrite. Immediately to the east of the shafts, the bluff of schistose diabase rises steeply for 20 or 25 feet, and on top of it, a few feet east of its margin, the schists enclose an irregular vein, up to three feet in width, composed of granular quartz carrying disseminated grains of pyrite. Attempts to obtain definite information concerning the work done in the shafts were without success.

The Huntingdon Mine—Range VIII, Lot 8, Bolton.—"The ore consists of the yellow sulphuret, and an excavation has been made on it, under the name of the Huntingdon mine, on the eighth lot of the eighth range of Bolton. Here is a bluff facing to the westward, in which the strata have an inverted dip of S. 62° E.<75°, and a band of serpentine of which only a small portion is exposed is succeeded to the eastward by a mass of green chlorite slates of various degrees of hardness, of which between fifteen and twenty feet, next to the serpentine, are all more or less impregnated with a mixture of copper pyrites and magnetic iron pyrites.

The following is a section of this metalliferous band, going eastward from the serpentine, which, the dip being an overturn, would be in descending order—

		Ft.	In.
1.	Greenish diorite with disseminated masses of copper pyrites and magnetic iron pyrites	2	0
2.	Compact granular copper and iron pyrites with disseminated small masses of quartz	1	4
3.	Magnetic iron pyrites interstratified with thin leaves of chloritic and micaceous slate	0	9
4.	Greenish diorite with disseminated copper and iron pyrites	1	0
5.	Compound granular copper pyrites with disseminated small masses quartz	2	6
6.	Green chloritic slate, with disseminated masses of copper pyrites, mingled with magnetic iron pyrites	8	0
		16	00

Since last August (written in April, 1866) a shaft has been sunk in that part of this deposit which is next to the serpentine, to the depth of about fifty-six feet, and at the depth of thirty-eight feet a gallery has been driven northward in the bed for a distance of about forty-five feet. The space excavated is equal to about twenty-five square fathoms in the plane of the bed, yielding, according to the estimate of Mr. Francis Bennett, who superintends the mine, about nine tons of eleven per cent ore per fathom. Of this about 140 tons of eleven per cent hand-picked ore have been sent to market, while a quantity of undressed material remains on the floor, sufficient to yield about eighty-five tons more of the same percentage, the value of such ore being $45 per ton." (J. Richardson in G.S.C., 1866, pp. 35-36.)

"Yellow sulphuret characterizing a breadth of 17 feet in hard and soft-chlorite slate, with serpentine on the west side. Upwards of three feet of the band, near the serpentine, is solid granular copper ore, while in the remainder masses of copper pyrites are mingled with magnetic iron pyrites." (G.S.C., 1866, p. 300.)

"During the year 1870, with an average force of not over 40 men and boys, 4,500 tons of ore at from six to twelve per cent produce have been raised, and for the most part shipped to Swansea. Contracts were made during that year to furnish from the Huntingdon mine, 1,000 tons of such ore per month. The lode at some parts has yielded as high as ten tons of twelve per cent ore to the cubic fathom." (A note on the Huntingdon mine in the Report on the Property of the Ives Mining Co., by Chas. Robb, 1872.)

"The ore at the Huntingdon mine consists chiefly of a chloritic slate and diorite, more or less impregnated with copper pyrites, pyrrhotite and iron pyrites. No mining is being done at present, but considerable quantities of ore, yielding between four and five per cent of copper, were raised in 1874. It was treated by the Henderson process, and up to the beginning of 1875, 1,500 tons of ore had been reduced and about $25,000 worth of copper produced. During the first six months of 1875, 4,012 tons of ore were treated and 299½ tons of precipitate, containing 75 per cent of copper obtained and sold for $66,300. In July last, the reduction works (owned by the Huntingdon Copper and Sulphur Company) were partially destroyed by fire, and since then only small quantities of ore have been reduced." (Catalogue of Economic Minerals of Canada, p. 28, Philadelphia International Exhibition, 1876.)

"During the year 1877 there was extracted from this mine 1,300 tons of ore, containing about seven per cent of copper and 1,600 tons, in which the proportions would descend to three and a half per cent. The first part was smelted and the other treated by the wet process; the matte and the precipitate obtained until the beginning of October have been exported to England. During the year they employed 65 persons at the mine and 35 in the reduction works." (Catalogue des Minéraux, Roches et Fossiles du Canada, Paris Exposition, 1878.)

"Work was begun on this property in August, 1865. From notes kindly furnished me by Capt. W. Warne, the present manager of the Memphremagog Mining Co.'s works, the management was in the hands of Capt. Bennett, of Lennoxville, who controlled operations till 1870-71, when the mine was sold to a Glasgow company and the name changed to the Huntingdon Copper and Sulphur Co., under the management of Mr. John Rudda, of Cornwall. The output under the old Company's management is stated to have been from 200 to 300 tons of ten per cent ore per month, part of which was shipped to England and part to the United States. Extensive buildings, etc., were erected, and under Capt. Rudda's management, the output was increased to 400 to 500 tons per month of seven per cent ore.

"In 1872 works were erected for carrying on the Longmaid or Henderson process, by which the ore was burnt in retorts to drive off the sulphur, but the process did not apparently meet with much success. The ore was then crushed, mixed with common salt, and calcined in furnaces and placed in vats with hot water and acid from the tower, and run off into other vats containing scrap iron, by which the copper was precipitated. Hundreds of tons of precipitate, containing 65 to 75 per cent of copper, are said to have been made in this way.

"In 1873 the works were destroyed by fire with a loss of $75,000. They were partially rebuilt, and mining was carried on in a desultory fashion for several years, and the Company finally closed operations in 1883. During the past year the property has passed into the hands of Messrs. G. H. Nichols & Co., of Capelton.

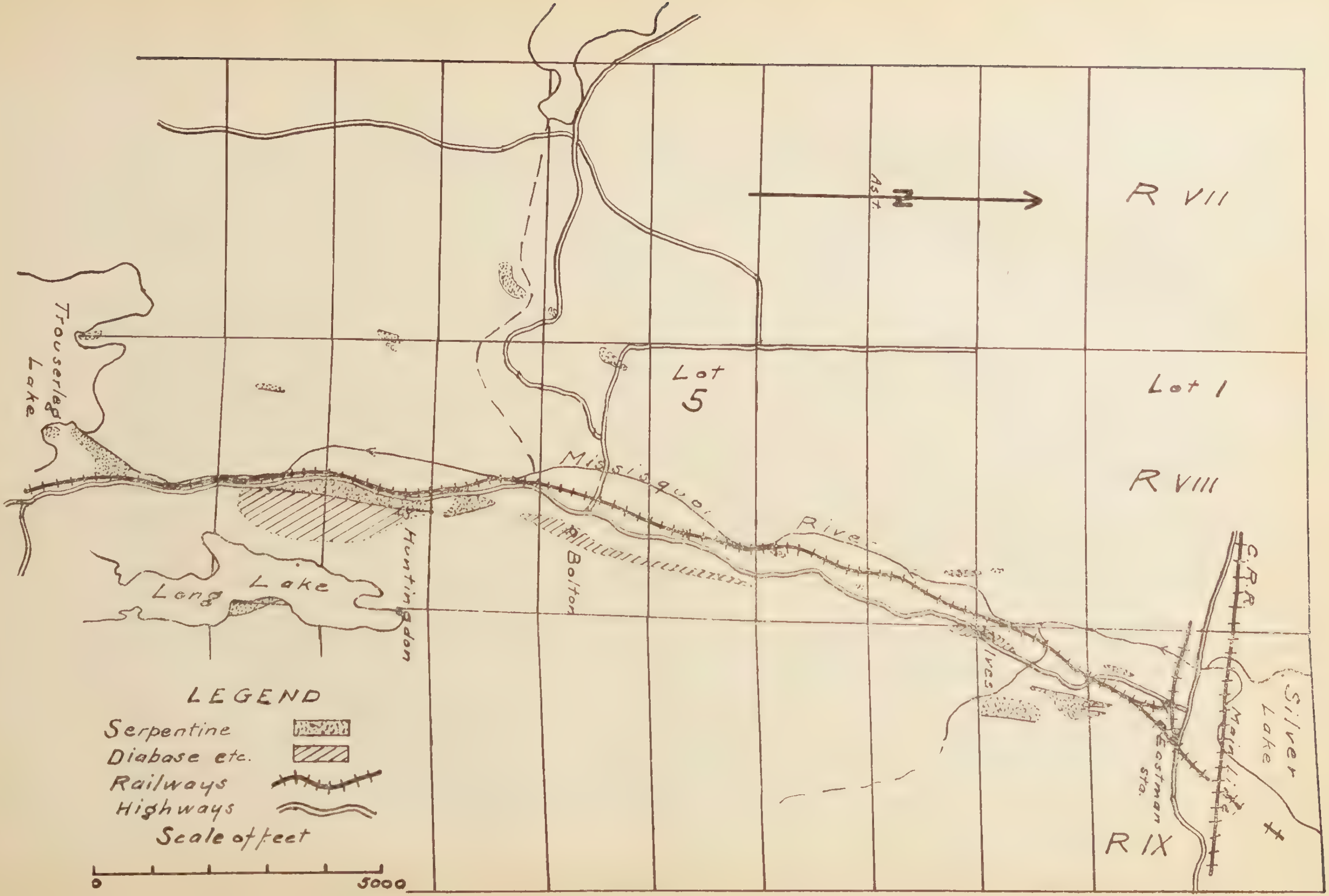
"In the working of this mine two deep shafts were sunk, one to the depth of between 500 and 600 feet, called the Huntingdon shaft, the other known as the Wright shaft, 200 feet deep." (Dr. R. W. Ells, in G.S.C., 1888-89, pp. 47 to 48K; also in G.S.C. Bulletin on Copper, 1904, p. 41.)

"The old Huntingdon mine was pumped out during the autumn of 1890 by Messrs. G. H. Nichols & Co., and some further underground exploratory work carried on in the vein of ore, but no details have been received as to the amount of work done or results obtained." (R. W. Ells in G.S.C., Vol. VII, 1894, p. 88J.)

"The ore forms a body some eight feet in width at the surface along the inner contact zone of a dyke with clastic rocks. There are no structural or other features to suggest secondary concentration of the ore, or that the deposit is other than an original segregation in the magna of the intrusive rock. The ore, of which large shipments were formerly made, is reported to have yielded an average of about five per cent copper.

"The mine has not been in operation for some years. During the period of its most successful operation the nearest railway was twenty-four miles distant. At present, a newly completed portion of the Orford Mountain Railway passes within a few yards of the shafthouse. (Report on the Copper Deposits of the Eastern Townships by J. A. Dresser, G. S. C., 1907.)

The Huntingdon mine is situated about three miles south of the village of Eastman, through which the main line of the Canadian Pacific railway passes, and also the Orford Mountain Railway, now a branch line of the C.P.R. To the south of Eastman, the Orford Mountain Branch passes within a few yards to the west of the main shafts of this mine. The mine is situated toward the northern end of a low ridge. The detailed geological relations are clearly shown in the map kindly prepared by Robert Harvie, Ph.D., of the Geological Survey, Ottawa. The ridge is composed of a body of serpentine with talcose schists and chlorite schists, the metamorphic equivalents of an intrusion that varied in composition from an olivine diabase to a peridotite that is in contact with slates developed through the metamorphism of sediments. Although the contact between the chlorite schists and the serpentine is comparatively sharp, it is believed that both the diabase and the peridotite



of Bolton Township (Prepared by R. Harvie, Ph.D. of the Geological Survey of Canada, Ottawa.)

were differentiated from the same magma in a somewhat irregular dyke-like mass that is steeply inclined toward the south-east. The heavier peridotite would appear to have segregated toward the footwall of the intrusion. The schists strike approximately N. 25° E. and dip steeply towards the southeast. To the east of the serpentine, apparently for a maximum width of about 15 feet, on the surface, the chlorite schists are very irregularly, though in part richly, impregnated with chalcopyrite, pyrite, pyrrhotite, and occasionally a little zinc blende. With variable width, this mineralized zone would seem to extend for about 150 feet; northward it terminates against serpentine; southward it seems to gradually die out. Although not observed by the writer of this report, Professor Edward Chapman, of the University of Toronto, in his report on the Ives mine, prepared in June, 1869, mentions that:—"In some heaps of ore at the Huntingdon mine, I observed here and there a few specks and particles of mispickel (arsenopyrite) but I have not found as yet a trace of that substance in the Ives ore."

At the western contact of the band of serpentine and talcose schists, chloritic slates are impregnated with similar sulphides; the width of this zone could not be satisfactorily determined. Concerning this more western mineralized zone, which is roughly parallel with the first, Mr. Charles Robb, in his report on the Ives mine, in February, 1872, writes:—"At the Huntingdon mine two parallel copper-bearing lodes or beds have been opened up and extensively developed, one on either side of, and both closely contiguous to, the serpentine and steatite bands. That lying to the west of this band and in immediate contact therewith has proved the richest and most important of the two." It is upon this zone that Mr. P. Tétreault of Montreal has recently been sinking a shaft; judging from Mr. Robb's statement it seems highly probable that within the mine considerable stoping has been done along this zone.

It is said that the Huntingdon mine was discovered by Mr. Avary Knowlton, an expert in the use of the divining-rod. This gentleman claimed that when he attached a copper coin to the end of his divining-rod, he experienced a disagreable feeling when in the vicinity of a deposit of copper ore.

The Huntingdon Mining Company commenced work on the property in August, 1865, and by the first of April, 1866, it had produced about 225 tons of nine to eleven per cent hand-picked ore. Until 1870-71, under the management of Captain Francis Bennetts, the production is reported by Ells to have been from 200 to 300 tons [1] of about ten per cent ore per month. Writing in 1872, Mr. Chas. Robb, [2] M. E., states that:—"Although not over six years since being systematically worked, and although the scale of operations has been very limited—owing chiefly to the disadvantage of distance from railway communication and the low price of copper—it has already produced large quantities of ore for the market. During the year 1870, with an average force of not over 40 men and boys, 4,500 tons of ore, of from six to twelve per cent produce, have been raised and for the most part shipped to Swansea, Wales."

Although it is rumored that the mine was not a financial success during the early period of working under the Huntingdon Mining Company, it was sold for a large sum of money to a Glasgow Company, and the name changed to the Huntingdon Copper and Sulphur Company, under the management of Mr. John Rudda of Cornwall. Under his management, extensive buildings were erected, and Ells states that the output was increased to from 400 to 500 tons [3] of seven per cent ore per month. In 1872, [4] it was estimated that over 25,000 tons of ore, holding from 3 to 3.5 per cent of copper, were lying at the mine; because of the large admixture of iron pyrites, this ore could not be dressed for shipment, and it was decided to erect works for treating it by the Henderson process. It is reported that in 1874 large quantities of ore, yielding between 4 and 5 per cent, were mined. Up to the beginning of 1875, 1,500 tons of ore had been reduced, and about $25,000 worth of copper produced. During the first six months of 1875, 4,012 tons of ore were treated and 299½ tons of precipitate, containing 75 per cent of copper, obtained and sold for $66,300. In July, 1875, the reduction works were burned, representing a loss of $75,000; and for the balance of the year, only small quantities of ore were reduced. For a considerable portion of 1876, no mining work was being done, but the reduction works were partially rebuilt. In 1877, 1,300 tons of ore, containing 7 per cent of copper, and 1,600 tons, in which the proportion would descend to 3½ per cent, were mined. The first part was smelted and the other treated by the wet process; the matte and precipitate obtained were exported to England. The mine was worked in a very desultory manner until 1883, when the Glasgow company finally closed down operations. For them it had not been a profitable venture.

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[1] Considered as a generalization, this estimate is undoubtedly excessive.

[2] A foot-note in the Report on the Ives Mine, by Chas. Robb, Feb., 1872.

[3] Considered as a generalization, this estimate is undoubtedly excessive.

[4] Notes on the Copper Deposit of Bolton, by Dr. T. Sterry Hunt, May, 1872, page.6.

Up to 1883, apart from a few relatively small openings, where prospecting operations had been performed, the mine was worked from two shafts. The more northerly, known as the Huntingdon shaft, is said to have reached a depth of between 500 and 600 feet; the other, called the Wright shaft, is about 200 feet deep.

In 1888, the property passed into the possession of Messrs. G. H. Nichols & Co., of Capelton. In the autumn of 1890, the mine was pumped out and prospecting operations were conducted until 1893. A short distance south of the Wright shaft, another shaft, known as the Nichols shaft, was extended to a depth of about 500 feet. In the course of their work, a few carloads of ore were shipped from the property.

In the summer of 1912, Mr. Pierre Tétreault, of Montreal, started to erect a concentrating mill with the intention of working over some of the old dumps. The building was completed, but the machinery was not installed. Under his direction also, a shaft was sunk, probably to a depth of about 40 feet, on the more western of the mineralized zones. In the spring and early summer of 1914, the water was pumped out of the old Nichols shaft down to about 275 feet. At a depth of 180 feet some prospecting was done, where they found the chlorite schist impregnated with small amounts of chalcopyrite and pyrite, and traversed parallel to the schistosity by narrow stringers of quartz carrying chalcopyrite. A month or more before the outbreak of the war, work was suspended on the property. Mr. Tétreault has purchased the property from the Nichols Copper Company.

During the early days of working, it was necessary to take the products of the mine by team to Waterloo, a distance of about twelve miles. In 1883, when the mine closed down, the average price of copper in New York was 16.50 cents, and the Waterloo and Magog railway was being constructed. In the early '90's, when the Nichols Company carried on extensive exploratory work on the property, the Canadian Pacific railway then passed through Eastman and the rails of the Orford Mountain railway had been laid past the property, but traffic on them had not been commenced.

Although, during the early period of working, the Huntingdon mine produced a relatively large tonnage of excellent copper ore, at the present moment it must rightfully be considered only as a prospect. It remains to be proved as to whether copper ore is yet present, in or adjacent to the old workings, in commercial quantities. It is also to be hoped that Mr. Tétreault can demonstrate that it is practical to concentrate the small copper content in some of the large dumps on the property.

Range IX, Lot 1, Bolton.—"On lot 1, range IX, Bolton, at Eastman village, a shaft about 15 feet deep on one wall shows a small vein with a lens of ore about one foot thick, containing chalcopyrite, sphalerite and pyrite. Owing to a fault the vein is not continuous across the pit." (R. Harvie in Summary Report G.S.C., 1911, p. 291.) In 1912, this shaft was sunk to a depth of 21 feet and at the bottom a drift was extended four or five feet to the southwest. Here a wedge-shaped mass of schistose sedimentary rocks (metamorphosed sandstones and shales) with its apex toward the southwest, extends into a comparatively small intrusive body of serpentine. The schists strike N. 24° E. with essentially a vertical dip. The shaft penetrates the schists, at a point about 120 feet and 30 feet respectively, to the northwest and southeast of which the serpentine outcrops. In character, form and mode of occurrence, the mineral deposit disclosed is a miniature edition of some of the larger of the copper and iron sulphide deposits of the Eastern Townships. On the southwestern wall of the shaft, a small lenticular vein of chalcopyrite, zinc blende, pyrite and occasionally a little chalcocite, pinches and swells so that *with a length that does not exceed 21 inches*, it varies in width from one to fifteen inches. Tapering to a point at either end, the vein of solid sulphides terminates, while continued in the direction of strike, a narrow band of the schists contains scattered grains of pyrite with a very few of chalcopyrite. Upon the northeastern wall of the shaft widely disseminated grains of pyrite are present in some narrow bands of the schist. Specimens may be collected from this tiny deposit that are composed almost entirely of black zinc blende, but, in general, chalcopyrite and pyrite predominate. Mr. Peter Racicot, upon whose property the shaft is situated, submitted specimens of the ore for assay to both Dr. J. T. Donald, Montreal, and to the Provincial Assay Laboratory,Ecole Polytechnique, Montreal. The one certificate shows the presence of—Gold 0.15 oz. per ton, silver 6.62 oz. per ton, and Copper 19.97%; the second certificate—a trace of Gold and 13.4 oz. Silver per ton, with 36.01% of Copper.

Although the results of the assays are most gratifiying, the deposit is far too small to be economically worked. From the surface to the present depth of 21 feet in the shaft, it shows no tendency to increase in size.

The Ives Mine—Range IX, Lot 2, Bolton.—"Yellow sulphuret with iron pyrites, partly magnetic, largely disseminated in chlorite slate, through a breadth of 15 feet with serpentine to the west." (G.S.C., 1866, p. 300.)

In June, 1869, a report on this property was prepared by the late Professor E. J. Chapman of Toronto, in which he states that:—"The amount of slack ore—*id. est*, ore that cannot be profitably hand-dressed for transportation—on the ground at the time of my visit was approximately 540 tons of about six per cent ore ("smalls") and 3,570 tons of about 4 per cent ore in several heaps. A considerable amount of ore, roughly dressed by hand to about thirteen or fourteen per cent, has also been boxed for market with in the last ten months."

In a report prepared by Mr. Charles Robb, M.E., in February, 1872, the folowing information appears:—"The total quantity of rock excavated at your mines in the underground operations may be roughly estimated at 400 cubic fathoms or 6,400 tons of 21 cwt. per ton; and the ore obtained and sent to market at 600 smelter's tons of twelve per cent produce; in addition to which there is now on the dressing floor about 35 tons of the same grade already dressed up, and a pile of rock estimated to yield about 40 tons when dressed. There is also a pile of *smalls* about 300 tons weight which will probably produce at least five per cent of copper; and a large pile of rock of which, being covered with snow at the time of visit, I could make no estimate either as to quantity or quality. The cost of mining, raising and dressing the ore to ten or twelve per cent produce ready for shipment at the mine, will probably not exceed twelve dollars per ton, including all actual working expenses, after the ground has been opened up for stoping. The freight and charges to England from the mine will amount to about eight dollars per ton."

In May, 1872, a report was prepared on this property by the late Dr. T. Sterry Hunt, then Chemist and Mineralogist to the Geological Survey of Canada. Since this is the most recent of these reports giving a complete résumé of the condition of the mine at that time, it seems appropriate to reprint considerable portions of it, as follows:—

"The strata, which have here a strike of about N. 35°E. magnetic, dip with a very high angle, about 80°, to the south-east and consist of soft, more or less chloritic schists with an included band of steatite or soapstone, sometimes with serpentine."

"The workings at the Ives Mine consist of two shafts, about 50 fathoms apart. Of these the southern or Brydges shaft was sunk for fourteen fathoms through good mining ground, and yielded 100 tons of 10 per cent ore in the sinking, besides ore of lower grade which has never yet been dressed. From this depth it passed downwards eleven fathoms through barren ground, the sudden appearance of which appears to indicate a local disturbance in the stratification. At a depth of 15 fathoms, a cross-cut was carried a distance of nine fathoms to the westward, until the bed of soapstone was met with; a portion of rich ore having been met in the cutting. A level, at this depth of fifteen fathoms, was then driven westward, along the eastern limit of the soapstone band, for fifty fathoms, through ground which in some parts holds so much ore as to be fit for stoping. At the northern extremity of this level a cross-cut was made to the eastward, when good ore was encountered, until at a distance of eight fathoms from the soapstone, a bed very rich in masses of yellow ore was met with. A shaft, known as the Galt shaft, was here sunk a little farther to the east, and, owing to the slope of the surface, reached the horizon of the so-called fifteen fathom level at a depth of twelve fathoms, without however encountering the ore stratum; which, owing to its eastward dip, was met with at the bottom of the shaft, eight fathoms below, or twenty fathoms from the top of the Galt shaft. At twelve fathoms, a level was driven along the strike of the ore bed for a distance of ten fathoms northward and thirty fathoms southward, or within eighteen fathoms of the Brydges shaft, which lies in the strike, and was sunk fourteen fathoms along the same ore bed. Rich ore-bearing ground was found throughout this level of forty-two fathoms, and considerable work has been done near the Galt shaft, where the ground on both sides has been stoped downwards for six fathoms. The accumulation of water, the only means of removing which is by a bucket, has prevented working at a lower level. The ore-bearing ground thus stoped along the twelve-fathom level varies from five to twelve feet, but has an average width of one and a-half fathoms, and yields to the cubic fathom an average of four tons of ore of thirteen per cent, besides about two tons of stuff estimated to contain six per cent of copper, which is accumulating at the mine for the want of dressing-machinery. The gangue is a soft chloritic and dioritic rock, calculated to weigh about seventeen tons to the cubic fathom, so that the yield for the rock raised is nearly four per cent of copper. The ore is pyritous copper, with a little iron pyrites and has assayed from twelve to fourteen per cent in Liverpool. About 200 tons of such ore are now ready for shipment, and it is estimated by Mr. Charles Whyte, the superintendent, that, with proper facilities for draining the mine and for dressing the ore, the present stopes could be made to yield equal to 150 tons monthly of ore of eleven per cent."

"In sinking the Brydges shaft, as already said, evidence of some disturbance was found at a depth of fourteen fathoms, and the rich ore-bed was lost. The cross-cut of eight fathoms to the westward showed some good ore, and thence the fifteen-fathom level (already mentioned as extending fifty fathoms to the northward) was carried twenty-five southward along the east wall of the soapstone, portions of ore being met with all the way, but no considerable quantity. From the bottom of the Brydges shaft, at the depth of twenty-two fathoms, another level parallel with this last (but of course farther to the eastward) was carried for seventeen fathoms to the southward. This is now filled with water, but is said to have yielded some ore throughout. It would now appear that the portion of the ore-bed which, in sinking the Brydges shaft, was lost at fourteen fathoms, lies between these two levels. In the course of April, 1872, exploration was re-commenced twenty-three fathoms southward from the Brydges shaft, in the fifteen fathom level, where a mass of ore was uncovered at the bottom of the level. A winze now sinking upon this shows, at the depth of two fathoms, the ore-bed, precisely as the stopes seventy-five fathoms to the northeastward having a breadth of nine feet, and yielding, according to the superintendent, four tons of twelve per cent to the cubic fathom; besides much ore of lower grade. It is proposed from this winze to communicate with the twenty-five fathom level at the bottom of the Brydges shaft; and from present appearances, another extent of ground as rich as that now worked farther northward, will, in the course of the summer, be so far opened as to double the production of the mine."

"The cost of ore from twelve to fourteen per cent from the present workings, all expenses included, is, according to Mr. Whyte, the superintendent, $12 per ton. To this may be added, for freight to Montreal, and thence to Liverpool, with charges, about $7.50, making the cost of such ore in Liverpool about 5 pounds sterling per ton. It is to be remarked that the operations here have, as yet, been limited to such ores as could readily be raised by hand-picking to the percentage just mentioned, and that no dressing machinery has as yet been erected. At my visit to the mine last week I saw, besides 200 tons of 13 per cent ore, 2,000 tons or more of rejected ores, holding about 4 per cent; which, at a very small expense, could be dressed to six or seven per cent, or even higher; the ore being in a soft chloritic gangue, and associated with comparatively little iron pyrites. Should it be desired to erect works on the spot for the extraction of copper by some wet process, large quantities of ore suited for this purpose might be extracted and dressed to 6 or 7 per cent, at a small cost, from various points along the ground already opened, both within and outside of the limits of the rich ore-producing portions already indicated."

"In a published report upon the Ives mine, made by Prof. Ed. J. Chapman of University College, Toronto, in June, 1869, he estimates at not less than fourteen feet, the breadth of ground capable of yielding four per cent of copper, or 1¾ tons of copper to the running fathom. This, however, is not in all parts as concentrated as in the somewhat narrower portion of ground now stoped (which yields by handpicking an ore of over 13 per cent) and therefore would require for the advantageous extraction of its metal either proper dressing machinery, or, as suggested by Prof. Chapman, the employment of a wet process at the mine. In his report he has assumed that the copper-bearing band will be equally productive throughout its whole extent, in which case the productive capacity of the ground becomes enormous. This continued richness of the ground remains to be proved, for the unopened portions, but in the meantime, the observations, as far as made, go to confirm it." (Private report by Dr. T. Sterry Hunt, May 1872.)

"Two shafts were here sunk, the Ferrier * and the Galt, the former to a depth of about 60 feet, the latter for 100 feet. This mine was opened in 1866 and worked for ten years, and a large quantity of from ten to fourteen per cent ore was extracted and shipped to England. These three mines (viz., Ives, Canadian and Huntingdon) are situated on the east side of the Missisquoi river, south of what is now known as Eastman, and are all probably located on the same belt of ore. The serpentine rock is found at all these mines, with slates of various colours, differing in this respect from the rocks of the second area or that west of the Sutton mountain. Very favorable reports on these deposits have appeared by Dr. T. Sterry Hunt and others, but the presence of the magnetic pyrites serves to distinguish the ores as a class from those already described." (R.W. Ells in G.S.C., Vol. IV, 1888-89, p. 48K; also in G.S.C. Bulletin on Copper, 1904, pp. 43-44.)

The Ives mine (Plate VI) is situated about two-thirds of a mile to the southwest of the Orford Mountain Railway station at Eastman village. Both this railway and the main waggon road, passing southwest from Eastman, cross the western end of lot 2, range IX. Near the southwestern corner of this lot, the railroad is approximately 125 yards west of the waggon road and in the space between these two roads the mining operations have been carried on. Three shafts were sunk in chlorite schists, the metamorphic equivalent of a long dyke-like intrusion of olivine-diabase that here possesses a width of more than two hundred feet. From a study of

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*The Ferrier shaft was sunk on range VIII, lot 4. The second shaft at the Ives mine was known as the Brydges shaft and was sunk to a depth of about 150 feet.

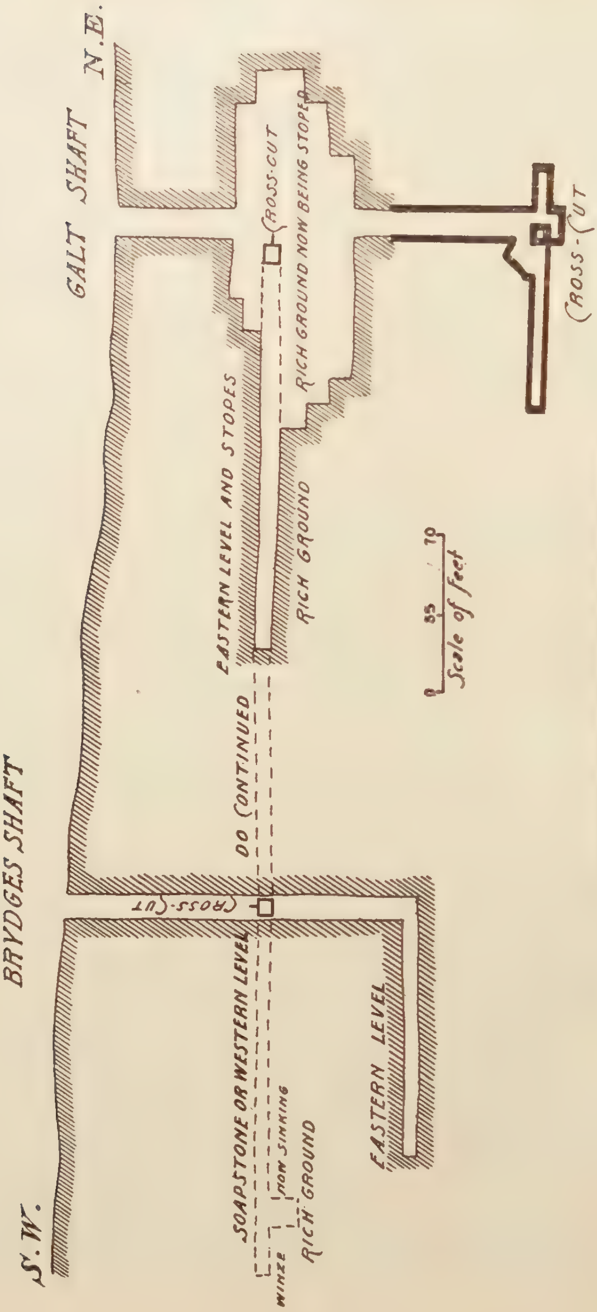

Fig. 6.—Plan of workings at the Ives mine, Eastman.

The shaded portion of the diagram is a reproduction of a plan published by Dr. T. Sterry Hunt, April 25th, 1872; that in heavy lines, unshaded, represents the recent work that has been done from 1911 to 1914.

the surface geology, it is not possible to locate the western margin of this intrusion, because in this direction the exposures of chlorite schists pass beneath the low alluvium-covered land of the valley of the Missisquoi river. The most western underground workings have encountered a talcose schist or soapstone, apparently the product of metamorphism of a more basic phase of the diabase intrusion. The chlorite schists strike about N. 35° E. and dip at an angle that varies from 80° to 87° toward the southeast.

The most northerly shaft, and one not mentioned in previous reports, is about 100 yards northeast of the shaft that was reopened in 1911 (known as the Galt shaft) and penetrates a zone of schist that lies about 25 yards eastward of that upon which the Galt shaft is situated. Sunk during the earlier days of working this property, (1866-1876) its exact depth is not known, although it is probable that it possesses a depth of at least from forty to fifty feet. Nothing of economic value was discovered in this shaft.

The two shafts, mentioned in many of the old reports as the Galt and the Brydges shafts, are situated about 100 yards apart upon a mineralized shear zone, striking N. 35° E, within which the schistosity is somewhat better developed. Of these the Brydges shaft is the more southerly, being situated close to the southwestern corner of the lot. The following is a brief résumé of the extent of the workings in these shafts on May 1st, 1872, when Dr. T. Sterry Hunt prepared the report on this property—(see the accompanying diagram reproduced from Dr. Hunt's report, Fig. 6)—from which quotations have been given above, the Brydges shaft was 150 feet in depth, barren ground having been encountered at a depth of 84 feet. At a depth of 132 feet a level was carried for 102 feet southward. At a depth of 90 feet a cross-cut was driven westward for 54 feet, encountering talcose schists or soapstone; from here, drifts were extended southward and northward for 150 feet and 300 feet respectively along the eastern margin of the soapstone; and 138 feet within the southward drift a winze,then 12 feet deep, was being sunk in a breadth of nine feet of good ore. At the northern end of the drift 300 feet in length, a cross-cut was driven 48 feet to the eastward where good ore was met with. A little to the eastward of this point, the Galt shaft was sunk to a depth of 120 feet, where it penetrated the mineralized shear zone that dips very steeply to the eastward. At a depth of 72 feet in the Galt shaft, levels were driven to the northward and southward along the mineralized zone for 60 and 180 feet respectively. Along this level both to the north and south of the shaft, the ore-bearing zone varied from 5 to 12 feet in width and with an average width of 9 feet had been stoped downward for 36 feet.

From a study of the old reports it is learned that to a depth of 84 feet, 100 tons of ten per cent ore had been removed from the Brydges shaft. The total quantity of ore shipped from the mine, up to February 1st, 1872, had been 600 tons, carrying twelve per cent of copper, while 75 tons of similar grade, 300 tons that would yield about five per cent copper and "a large pile of rock for which no estimate of quality or quantity" is given, had accumulated at the mine. Up to that time 6,400 tons of rock of 21cwt. per ton had been removed from the mine. By May 1st, 1872, 200 tons of ore, estimated to yield 13 per cent of copper, were ready for shipment and 2,000 tons (evidently this is an estimate of the large pile of rock for which no estimate is given in Mr. Robb's report of February 1872), or more of rejected ores, holding about 4 per cent, which at a very small expense could have been dressed to 6 or 7 per cent or even higher, had been collected in piles.

Although it is stated by Ells that "this mine was opened in 1866 and worked for ten years," it would seem that comparatively little work was done after 1872. In May, 1911, under the direction of Messrs.W. A. Cromwell and N. Parker, of Eastman, the water was removed from the Galt shaft. They found this shaft to be about 110 feet in depth, and that at a depth of 100 feet large stopes had been developed along the mineralized zone, especially northward from the shaft, where varying in width from seven to fifteen feet, the stope, according to Mr. Cromwell, is in places 50 or 60 feet in height.

In the course of the recent work, they have removed 8 to 12 feet in depth of rock and ore from the floor of the northerly portion of this stope. The shaft has been extended to a depth of 185 feet. From the bottom of the shaft a drift extends 22 feet to the northeastward. Within this drift, copper values are very low; at the face, near the western wall, a zone of the schist, three to five inches in width, is heavily impregnated with pyrite and a few small particles of chalcopyrite, while in addition some cubical crystals of pyrite are dispersed in linear arrangement parallel to the schistosity in the remaining portion of the schists here exposed. A cross-cut, which has been driven for fifteen feet eastward from the bottom of the shaft, lies within barren schists.

Southwestward from the bottom of the shaft, the mineralized zone has been followed by a drift for 72 feet. Within this drift, some very excellent copper ore has been encountered, occurring in the form of parallel veins, composed of chalcopyrite with some quartz and occasionally a little pyrite, that trend parallel to the schistosity. The average width of the sheared zone within which these veins occur is about five feet. No statement expressing the relative amount of schist and of veins in any one cross-section of the drift would possess worth because such a ratio is extremely variable. The individual veins or stringers of rich ore usually are a few yards, occasionally a few feet in length; along the strike other similar veins may or may not take the place of a vein that has died out. The veins pinch and swell; one of them, almost solid chalcopyrite, was observed to attain a width of 16 to 18 inches In addition to the veins, cubical crystals of pyrite, up to one and a half inches across, some grains of chalcopyrite and some, more finely diffused, particles of pyrrhotite, are dispersed parallel to the schistosity of some portions of the schist between the veins.

Along this drift for, about 26 feet from the shaft, they passed through a well mineralized portion of the zone, four to six feet in width, containing much high grade ore. Between 26 and 34 feet from the shaft, practically barren schist was encountered; beyond this to the face of the drift (for 38 feet) similar chalcopyrite-quartz veins and narrow zones impregnated with pyrite and chalcopyrite are enclosed within the schist. The face of the drift is four feet in width; for 15 inches from the eastern wall, a few scattered grains of pyrite and chalcopyrite are present in the schist, then a band one or two inches in width, chiefly composed of cubical crystals of pyrite, then follows 16 inches of barren schist, while the remaining 16 inches includes veinlets of chalcopyrite and quartz, one of which varies from one to four inches in width.

This somewhat detailed description should make plain that work is being conducted along a sheared zone within which the copper-bearing veins and stringers are irregularly distributed.

No sampling was done but, if, as seems probable, the mineralized zone be considered to have an average width of five feet, then between the bottom of the old stope (110 ft.) and the drift at bottom of shaft (185 ft.), it is estimated roughly that 2,000 tons of ore-bearing ground has been blocked out that probably would carry on the average three or four per cent of copper. By hand-picking, much of the ore can readily be dressed to a grade of from 9 to 12 per cent. In addition there is considerable ore between the top of the old stope to the southwest of the shaft and the surface. On August 25th, 1914, when this property was examined by the writer, about 20 tons of ore, that would carry approximately from 10 to 12 per cent of copper, was stored in the shaft-house. In 1911, stripping and trenching, a few yards to the east of the Galt shaft, exposed the mineralized shear zone along which stopes were developed in the earlier workings.

All of the work has been done by hand labour. For some time prior to my visit, they had no hoist and for this reason they began a small stope to the south of the bottom of the shaft, leaving all of the ore thus stoped in the bottom of the mine.

Since reopening the mine, six carloads of about thirty tons each have been shipped, five of which were taken from the mine and yielded nine and a half per cent of copper, while the remaining carload, selected from a portion of the dump, carried five per cent. In selecting the ore shipped from the dump, about an equal quantity of rock carrying less copper was cast aside. Without very considerable work, it would not be possible to approach an exact estimate of the amount of ore that lies in the dump, but on the basis of the shipment made, there must be a few hundred tons that will yield from three to four per cent of copper.

In the recent work, no attempt has been made to remove the water from the Brydges shaft, which in addition contains much rubbish. Upon cleaning out the Galt shaft, the long drift that follows the eastern margin of the soapstone was found to be inclined toward the Brydges shaft, so that it now contains water. Mr. W. A. Cromwell informed me that on one occasion they had pumped the water out of this drift and found that it penetrates practically barren schist.

Although at present in a developing or prospect stage, the recent work has shown that the Ives mine is a property that with a modest modern equipment gives promise of producing profitable results. In so far as is known at present, its future outlook seems restricted to that portion of the shear zone that, with a present width of from four to six feet, extends for from 150 to 200 feet southwest of the Galt shaft. With increased depth that portion of the shear zone upon which work has recently been conducted may widen somewhat as it did locally in the upper workings. Further work along its strike may reveal other portions of the shear zone that have been well mineralized. Prospecting, conducted by a diamond drill, may possibly reveal other parallel mineralized portions, although none may be seen in a study of the rather restricted rock exposures in the vicinity. Shortly before the outbreak of the present war, operations were suspended.

Range IX, Lot 3, Bolton.—Near the northwestern corner of this lot, approximately 100 yards from its boundary with lot 3 and about 50 yards east of the road from Eastman to Bolton Centre, South Bolton, etc., a shaft is situated that undoubtedly represents an unsuccessful attempt to locate a continuation of the vein of the Ives mine, a description of which immediately precedes this. The shaft, which is well timbered, passes through several feet of glacial drift into chlorite schists similar to those of the Ives mine. Its depth was not learned, but the fragments of schist on the dump display no evidence of mineralization apart from the presence of a very few widely scattered grains of pyrite.

Range XII, Lot 3, Bolton.—A few years ago, two shafts were sunk near the northeastern corner of this lot, less than a mile from the Orford Mountain station on the Canadian Pacific railway. Situated at the foot of a northwest slope of quite an abrupt exposure of an intrusive igneous rock, that in the field was called a diabase, and with a barrier of three or four feet of rock between them, the more eastern shaft is said to have a depth of 20 to 25 feet, and the other of 12 to 15 feet. In irregular patches the rock is rusty on weathered surfaces, because of the presence of disseminated pyrrhotite with a very little pyrite. The shafts were sunk at points where, in so far as exposures are concerned, the most pyrrhotite is present within a maximum width of about ten feet. Occasionally a little staining shows the presence of traces of copper. Very little of the material removed from the shaft approaches the state of being practically solid pyrrhotite. When discovered, a "capping" of limonite, from one to two feet in thickness, was present over an area of a few square yards. In the mineralogical character of the "ore," in the petrographical character of the rock with which it is associated, and in the presence of limonite as gossan, this occurrence is a miniature edition of the deposit of pyrrhotite, carrying a little copper, at the Lake Memphremagog (Smith's or Potton) mine on lot 28, range IX of Potton township. Apparently the pyrrhotite was deposited by waters that circulated along cracks after the diabase cooled.

Slickensided surfaces in fragments of the "ore" show that subsequent to mineralization, minor movements have taken place. Some of the more solid pyrrhotite has a foliated appearance; in thin section under the microscope it is found to be composed of very finely granular pyrrhotite, within which small grains of calcite are distributed in a linear arrangement corresponding in direction to the foliation.

Brompton Township.

Range IV, Lot 6, Brompton.—Toward the southwestern corner of this lot, a shaft was being sunk which, on August 15th, had reached a depth of 40 feet. The work was being carried on under the direction of Mr. John McCaw, of Sherbrooke.

Within this portion of Brompton township several small bodies of serpentine, associated with diabase or a fine-grained gabbro, intrude the metamorphosed sediments, now chiefly slates and schists. The serpentine and especially the diabase types are locally schistose or display a tendency to schistosity, the trend of which corresponds to the regional strike. Along certain irregular bands or zones the schistosity is more intense than along others.

The shaft follows such an irregular shear zone in serpentine of a black or dark green colour, which traverses the rock N. 47°E. and dips about 85° toward the southeast. One rolling fracture or irregular shear plane in the serpentine extends from the top to the bottom of the shaft. This forms a footwall above which the serpentine is traversed by the very irregular curved fractures that so frequently characterize this type of rock. Within some of these fractures, picrolite and a little magnetite are present, while, apparently later than the picrolite, some chalcopyrite has been deposited. Small octahedra of magnetite are scattered through the serpentine, and some crystals and grains of this mineral have been developed contemporaneously with the deposition of the chalcopyrite. It seems probable that the magnetite has been liberated during the alteration of the original peridotite to serpentine.

The chalcopyrite is very irregularly distributed in small nests or bunches and in grains distributed along some of the fracture planes in the serpentine. The largest kernel of pure chalcopyrite observed was a little larger than a walnut. On the northeastern wall at the bottom of the shaft, within a width of four feet, three irregular fracture planes displayed small amounts of chalcopyrite dispersed along them. Upon the southwestern wall, at the bottom of the shaft, two similar fractures were present. Tracing these fractures upward it is found that they die out, while others may or may not take their place. Adjacent to these fractures, occasionally the serpentine, for a width of two or three inches, contains disseminated grains or minute veinlets of the chalcopyrite. In general, however, the serpentine between such fractures is barren.

At the time of my visit very little ore could be found in any part of the shaft, while it was very evident from an examination of adjacent rock exposures that in attempting to drift in either direction, absolutely barren rock would be encountered almost immediately. Three to four tons of beautiful ore, possibly carrying six or seven per cent of copper, had been accumulated at the mouth of the shaft. Specimens very rich in copper values may be selected, but when the amount of ore is considered in the light of the work done and of the manner in which the ore occurs, it is plain that the shaft shows no indications that would encourage the continuation of the prospecting work at this point.

A short distance to the southeastward from this shaft, another opening was made to a depth of 11 feet in an altered diabase or a fine-grained gabbro, which is closely related to the serpentine in that it is a product of differentiation of the peridotitic magma of which the serpentine is the metamorphic equivalent. Here the rock exhibits a marked tendency to schistosity. The shaft contained water, but it was learned that less chalcopyrite was found than in the deeper shaft described above. Here a few grains and films of chalcopyrite are distributed irregularly along incipient planes of schistosity.

At other points upon the property narrow shear zones in the serpentine, usually a few inches in width and a few feet in length, are rusty upon exposed surfaces because of the presence of disseminated grains of chalcopyrite accompanied by small crystals and grains of magnetite.

GARTHBY TOWNSHIP.

In so far as could be ascertained, no copper ore has been shipped from this township.

Range I. S. E.—Lots 26 and 27, Garthby.—This prospect is situated four to five miles southwest from Coleraine Station on the Quebec Central Railway. The owner is Mr. Honoré Vézina, of Disraeli.

Both of these lots are covered with bush. In the vicinity of where the brook flowing toward East lake crosses the line between these lots, narrow irregular rusty patches appear upon exposures of diabase. The rusty appearance is due to the presence of some disseminated grains of pyrite with a very little chalcopyrite distributed along narrow zones of shearing, not exceeding, and usually much less than, two feet in width. Occasionally veinlets of quartz carrying these sulphides are present within these zones. On lot 26, an opening has been made to a depth of a few feet where, within a width of eight feet, three narrow veins of quartz and pyrite with a few scattered grains of chalcopyrite, none of which become more than two or three inches in width, traverse the diabase. At a few other points in the vicinity, some stripping has been done and a few small blasts of dynamite discharged in the bed-rock. None of "the discoveries" made thus far are of the least economic value. Work was commenced at once, prior to the examination of rock exposures, upon the adjacent portions of these lots; such surface prospecting should be done.

The Garthby Copper Mining Company—Range II, S, Lot 19.— "Some very active prospecting was done by the Garthby Copper Mining Company on lot 19 in the second range of the township of

Garthby. Some ten men were employed for three months, opening up a vein of chalcopyrite. The results are said to have been very encouraging and it is intended to push the work during 1913." (Report of Mining Operations in the Province of Quebec during 1912." Bureau of Mines, Quebec, p. 25.)

"Prospecting work was done on lot 19, range II, south, Garthby, where a shaft was sunk and stripping on a quartz copper-bearing vein." (*Ibid* during 1913, p. 46.)

This property is about six miles from Garthby station on the Quebec Central Railway. The prospecting work was confined to the northeastern portion of the lot, where a few acres were cleared, the remainder of the lot being covered with bush. Three openings have been made in the bed-rock; some diamond drilling and considerable stripping have been done. All of this work has been performed in diabase which in part displays both amygdaloidal and porphyritic structures; the diabase is more or less altered, and in places is traversed by quartz veinlets.

About 40 yards and 10 yards respectively, from the northern and eastern boundaries of the lot, a trench-like excavation has been made to a depth of about four feet, where the diabase is intersected by a few quartz veinlets, none of which exceed an inch in width. The diabase displays a tendency to schistosity, striking about N. 45° E. and dipping very steeply toward the east. A few grains of pyrite are present in the quartz, and also, together with a very few particles of chalcopyrite, are disseminated very irregularly within small portions of the rock exposed.

About 25 yards farther southward, an opening, with a maximum diameter of 13 feet, has been sunk to a depth of 14 or 15 feet. Here the rock is traversed by a few narrow shear zones that extend for a few feet or yards, and upon dying out in the direction of their strike, may or may not be continued by similar zones. Small irregular veins of quartz are present in the narrow shear zones and they, as well as the adjacent rock, contain some pyrite and a little chalcopyrite. A few specimens, more than one-half composed of pyrite and a little chalcopyrite in quartz, up to the size somewhat larger than a man's head, may here be collected; but such specimens are very exceptional. These sulphides are very irregularly distributed along the shear zones and in the more amygdular portions of the rock. Within any selected width of a few feet of what may be referred to as the mineralized zone, there is a great preponderance of barren rock.

About sixty yards farther south and also near the eastern boundary of the lot at the foot of an exposure about 25 feet high of similar diabase, is an irregular excavation with a maximum depth of 6 or 7 feet. Here the rock is in part somewhat more amygdaloidal than in the other openings, the amygdules being filled with quartz occasionally containing particles of pyrite and less frequently a little chalcopyrite. Mineralization is even more irregular than in the larger opening just described.

Within the vicinity of these excavations, at least three diamond drill holes have been put down. It was not learned to what depth these holes extended, but I was informed on good authority that the results obtained were very disappointing. There are no indications that, even if the property were adjacent to a railway, would warrant the revival of prospecting operations upon that portion of the lot that has been cleared of bush.

The Garthby (or Lac Coulombe) Mine—Range I, N and Range I.S., Lot 22 Garthby.—Apparently the earliest reference to this property is in the "Descriptive Catalogue of the Economic Minerals of Canada (p. 16) sent to the London International Exhibition for 1862," where it is described as follows:—

"This appears to be a large mass of iron and copper pyrites, subordinate to the strata, which here consist of calcareous serpentine, and run N.E. and S.W. with a dip of about S.E. 50°. The entire thickness of the mass is uncertain, but the breadth in which the sulphurets are more or less mingled with the rock is probably not less than twenty feet. In some parts, sulphuret of iron prevails, almost to the exclusion of that of copper; some parts assume the aspect of what, among Cornish miners, is termed *bell-metal ore*. An opening has been made in the mass eight feet in length, four feet in height and four feet wide; in this, the two sulphurets occur unequally mixed with one another, but nearly free from the rock of the country." (Catalogue of Econ. Min. of Can. 1862.)

"In the Township of Garthby, on the 22nd lot of the first range, north, a large mass of iron and copper pyrites is found subordinate to the stratification of the enclosing rock, which is a calcareous serpentine, dipping to the southeast at an angle of

50°. The extent of the deposit has not yet been determined, but there appears to be a breadth of about 20 feet in which the two ores occur, more or less intermingled with rock. Large masses of the mineral consist of fine-grained iron pyrites, without any copper, while in other portions there is such an admixture of copper pyrites as to afford 8 per cent of the metal. The iron pyrite of this locality, when exposed to the air, is slowly oxidized and falls to pieces from the formation of sulphate of iron; for the manufacture of which it might be used with advantage." (Geology of Canada, 1863, p. 733.)

"In the township of Garthby, on lot 22 on the first range north, there appears a large mass of iron and copper pyrites subordinate to the stratification, which consists of calcareous serpentine. The entire thickness in which the sulphurets are mingled with the rock is over 20 feet. Samples of copper have been broken from the mass, yielding by assay as much as 22 per cent, whilst samples of sulphuret of iron have also been broken, which, on being submitted to assay, were found almost entirely free from copper."

"An opening was made on this a couple of years ago, and sunk to a depth of about ten feet, and the sulphurets were found to continue for that depth with some regularity. A shaft was then commenced a little distance to the southeast of the outcrop of the mass, the object being to prove its nature at a depth of about ten fathoms from surface. This reached a depth of between seven and eight fathoms, when the quantity of water met with was such as required the aid of pumping machinery to enable the work to be proceeded with, and the same was in consequence suspended." "(Copper Mining in Canada East" by Herbert Williams, M.E., Quebec Lit. and Hist. Soc. 1865, pp. 49-50.)

"Yellow sulphuret with iron pyrites in calcareous serpentine." (G.S.C. 1866, p. 318.)

After quoting the above reference from the Geology of Canada, 1863, Ells adds:—"The ore at this place occurs in rocks differing in age from those of the area just described, being more closely allied to the deposits of Bolton and Potton. The first opening was made by Mr. J. Coulombe in 1860, and was nine feet long, five feet wide and said to be sixty feet deep. No work was done on the property after 1861. An analysis of the iron pyrites apparently free from copper gave:—iron 42, sulphur 48, copper 1.1, silica 8.9. This property is about 4 miles from the Quebec Central Railway, and recent explorations during the past year, in the southern part of the area, are said to have developed a large body of ore, the measures being traced into South Ham for a distance of three miles, but no definite information can be obtained on this point." (G.S.C. 1888-89, pp. 56K-57K; also in G.S.C. Bulletin on Copper, 1904, pp. 52-53.)

"In lot 21, range I of Garthby, there is a deposit of similar ore (immediately after a description of Lake Memphremagog mine), which is apparently of important size. It is known as the Garthby or Lac Coulombe mine. A shaft, said to be 50 feet deep, has been sunk, and apparently much of the output remains on the ground. The shaft seems to be sunk in solid ore. The surface stripping has not been sufficient to make it possible to estimate, even approximately, the size of the ore body." ("The Copper Deposits of the Eastern Townships," by J. A. Dresser, G.S.C. No. 975, 1907, p.15.)

"The road, which runs northwest from Garthby station on the Quebec Central Railway, crosses directly over a lens of pyrite on lots 22 of the first ranges north and south of the township of Garthby. Prospecting pits occur on both sides of the road, about five miles from the railway, and within a few hundred yards of Lake Coulombe. At present the old pits are full of water and little can be learned about the nature of the deposit. The old works appear to have been chiefly in ore, and there is a small amount of nearly pure iron pyrites piled beside the road. This ore appears to be of good quality. A sample gave the following analysis—Al_2O_3 0.24 per cent, Ca O—0.20 per cent, MgO—0.30 per cent, Cu—.36 per cent, S—45.32 per cent, Fe—40.45 per cent, Insoluble 11.00 per cent. The surrounding country is covered with soil and bush. The extent of the ore body could not be ascertained from the surface exposures. No records of the old mining operations are available." ("Pyrites in Canada", by A. W. G. Wilson, pp. 58-59, 1912, Mines Branch, Ottawa.)

"Chalcopyrite is found in small quantities, apparently as primary segregations, near the outer edges of the diabase in many places in this district. Most of them, however, are mere mineral occurrences, and not of commercial importance.

On lot 22, range I, of Garthby, is the property known as the

Coulombe mine, on which a shaft was sunk over forty years ago. The ore is a compact pyrite carrying a small copper content. It is extremely free from silica, and might be useful in conjunction with some of the siliceous copper ores of the Capelton district.

While there is little facility for finding the limits of the ore-body, the extent over which isolated exposures are found, indicates the possibility of an important body, perhaps like one of those found under similar conditions to the southwest of the district, at the Huntingdon and Lake Memphremagog mines." ("Serpentine and Associated Rocks of Southern Quebec," by J. A. Dresser, G.S.C., Memoir No. 22, 1913, p. 97.)

This property is situated about five miles from Garthby station on the road leading northwest between range I. N. and range I. S. These lots are now covered with a second growth of spruce, etc. Apparently, very little work has been done here since 1860 to 1863, when there was no railway in the vicinity and when, as Mr. Herbert Williams stated in 1865, work was suspended because of the need of pumping machinery. In 1889, some prospecting work was done in the old shaft, but no information seems to be available concerning the results obtained at that time. Very little evidence can be gathered concerning the possible size of the deposit. In its proximity, rock outcrops are confined to the northern side of the road, the land on the southern side being low, as in this direction one passes within a short distance to the small stream that enters the northwestern bay of Lac Coulombe.

At the northern margin of the road is an open cut of irregular shape with a width of twenty feet and an equal maximum length. To a depth of ten feet, this opening has been made in chlorite schists that have been formed through the metamorphism of a diabase. The schists strike N. 55° to 60° E. and dip 50° toward the southeast. Under the microscope, a thin section of the dark chlorite schist, from the southeastern side of the open cut, was found to be composed of much plagioclase and chlorite, a little calcite and leucoxene and a few small grains of black iron ore. In relationship to the chlorite, that has developed from the alteration of augite, the laths of plagioclase feldspar still display the ophitic structure. The feldspar is slightly turbid, but is remarkably fresh when one considers how thoroughly the other primary minerals have been changed. A thin section of the lighter coloured schist on the northwestern or footwall side of the excavation shows it to be the same rock, but more thoroughly metamorphosed, the feldspars having been largely replaced by or altered into quartz. Mineralization has taken place along a zone of shearing, within which the schistosity is best developed. It will be observed that in the above quotation from other reports, it is stated that massive pyrite, with occasionally a little chalcopyrite, "mingled with the rock" within a width of twenty feet and continued with some regularity to the bottom of this opening. Toward the north and east of this opening some trenching was done, but apparently without revealing anything of value.

Four or five yards south of the road and about twelve yards southwest of the opening described above, the shaft is situated. According to Mr. Williams, this shaft is between "seven and eight fathoms" (42 to 48 feet) in depth. No rock is exposed in the vicinity of its collar, but the very few fragments of rock on the adjacent pile of ore are similar to those of the open cut.

The ore is an excellent grade of very massive pyrite, somewhat lighter in colour than usual. It is certain that *the ore exposed on the dump will not average a half per cent in copper*, but will run high, probably about 45 per cent, in sulphur. One must search carefully in order to observe a visible trace of the presence of copper. A specimen that was examined in thin section under the microscope was found to be composed entirely of pyrite and quartz. More than four-fifths of the specimen was pyrite, mostly granular, but in part displaying a tendency toward cubical crystals; the interstitial spaces are occupied by very finely crystallized quartz.

Undoubtedly a lenticular body of pyrite is present at this locality, but to-day its dimensions are unknown. The open cut appears to be situated in the northeastern extremity of this body. Although some specimens from here have yielded values in copper, it is very premature to designate the property as a copper mine. It is a prospect that might prove attractive to those desirous of securing a deposit of pyrite. The main road to the railway is hilly, but it is said that an old sled road, following the brook flowing from Lac Coulombe to Lac Aylmer, possesses a more reasonable gradient. Possibly during development work, it would prove advisable to let the ore accumulate during the summer and transport it to the station while snow is on the ground.

CHAPTER VIII.

COPPER DEPOSITS OF HATLEY, ASCOT AND STOKE TOWNSHIPS.

HATLEY TOWNSHIP

In so far as could be learned, no copper ore has been shipped from Hatley Township; certainly not from any of the prospects described in the following pages, although these include those to which reference is most frequently made.

The Reid Hill Mine—Range I, Lots 27 and 28, Hatley.—"On the 27th and 28th lots of the first range of Hatley, yellow sulphurets of copper and iron in soft nacreous slates make a considerable display, in consequence most probably of repetitions of the deposit through minor undulations, giving, in the breadth of a quarter of a mile the appearance of no less than six beds characterized by the ore and having a dip S. E. 45°. They occur on the summits and slope of a hill about 500 or 600 feet above the Massawippi river and constitute the Reid Hill mine. Much rock has been blasted to expose the ore at the surface, and an adit is being driven on the southeast side of the hill at a level about 200 feet below the outcrop of the bed; but though this has been carried in about 200 feet, it has not yet reached the ore-bed."—(Jas. Richardson in G.S.C., 1866, p. 42.)

"Yellow sulphuret associated with iron pyrites in soft chloritic slate. This is the Reid Hill mine."—(G.S.C., 1866, p. 305.)

"The only other mine (apart from the Parnell mine) located in this township is that on lot 28, range 1, known as the Reid Hill mine. It has an elevation of 500 to 600 feet above the Massawippi river and presents the appearance of six beds of the yellow sulphuret, with iron pyrite, in a space of a fourth of a mile in breadth. Similar ores appear on the lots to the west on ranges two, three and four adjoining. Considerable exploratory work was done at this place, and a level was driven in about 200 feet below the outcrop of the bed, but no details of the workings or subsequent exploration are to hand."—(R. W. Ells in G.S.C., Vol. IV, 1888-89, p. 49k-50k; also in G.S.C. Bulletin on Copper No. 882, 1904, p. 45.)

Five hundred yards south of the Hatley-Ascot line, and about 375 yards east of line between ranges I and II of Hatley (apparently on lot 28, though close to lot 27), a tunnel has been driven into the southeastern slope and from 100 to 200 feet below the summit of a steep hill. Through collapse of the roof near its entrance, access to the tunnel is blocked. The tunnel was driven through sericite and chlorite schists, striking approximately N. 60° E, and dipping 45° to the southeast. Five years ago, the tunnel was reopened, when, as Mr. H. Astbury informed me, it was found to be between 250 and 300 feet in length and the rock through which it passes displays no better evidences of mineralization than may be seen in the fragments upon the dump. Such fragments show that they encountered a few narrow bands of schist, up to three inches in width, that contain disseminated grains and small crystals of pyrite. One or two small particles of copper pyrites may also be found. Apparently the miners driving this tunnel aimed to extend it beneath certain irregular bands of the schist that outcrop upon this hill and weather rusty because of the presence of scattered grains of pyrite.

Northward from this tunnel and about 200 yards from the Hatley-Ascot line, a shaft, 11 feet in depth, has been sunk upon a rusty quartz vein in sericite schists. Some of the milky quartz within this band, which varies from two to three feet in width, contains disseminated grains and crystals of pyrite. Five years ago a shaft was sunk on the southeastern slope of the same hill on the northern portion of lot 27, and 200 yards to the east of its western boundary. On a slope of about 60° to the southeast, corresponding to the dip of the schists, this shaft reached a depth of twenty-five feet. A vein of granular quartz of light gray colour, about three feet wide, is banded with veinlets of pyrite, and abundant small disseminated crystals of pyrite that, in general, are distributed along planes parallel to the schistosity of the enclosing sericite schists. In thin section under the microscope this vein is found to be a mosaic of small quartz grains, within which, along lines of shearing, small crystals of pyrite, irregular grains and rhombohedrons of an iron-bearing carbonate and a few minute flakes of chlorite are present.

Within the shaft a dyke of camptonite, three feet in width, cuts the schists and the vein.

About fifty feet further down on the slope of the hill, a tunnel has been driven into the hill for sixty-eight feet, passing directly beneath the shaft, which as a result is dry. Forty feet within this tunnel, the same vein was encountered and a winze was sunk upon it to a depth of fifteen feet. Beyond the winze the tunnel was driven for twenty-eight feet, intersecting the camptonite dyke, which here has a width of about four feet. The camptonite is remarkably fresh, nearly black in colour, and in hand specimens displays abundant needle-crystals of hornblende, up to half an inch in length. In thin section under the microscope, it is found that crystals of hornblende, with a few small crystals and grains of augite, comprise slightly more than one-halfof this rock; other constituents being plagioclase, numerous small grains of black iron ore, minute crystals of apatite, and a little secondary calcite. Some of the hornblende crystals exhibit a beautiful zonary structure.

At none of the points where work has been done upon this lot, do the indications suggest that prospecting operations should be renewed.

Range II, Lot 28, Hatley.—"Yellow sulphuret occurring in chloritic slate, the character of the deposit being the same as that of the Reid Hill mine. The Massawippi Mining Company hold the mining rights."—(G.S.C., 1866, p. 305.)

Symbols indicating the occurrence of copper upon this lot appear both on the geological map of the Eastern Townships that accompanies Part J, Vol. VII, 1894, of the G.S.C. and on the Mining Map of Ascot Township, published in 1908 by J. Obalski, then the Superintendent of Mines of Quebec.

Upon the northern portion of this lot, in the vicinity of the road passing approximately from north to south across this range, considerable work was done at the same time as that on lot 1, range XI, Ascot.

About 35 yards from the Hatley-Ascot line, and 40 yards west of this road, is a shaft which is said to be about 30 feet deep. Now partially filled with rocks, this shaft penetrated chlorite schists, traversed, parallel to their schistosity, by irregular quartz veins, one of which attained a maximum width of 16 inches. Small crystal and grains of pyrite are sparsely disseminated within the quartz veins and in some narrow bands of the schist. Within some fragments of the quartz, a very few particles of copper pyrites also were observed to be present.

About 75 yards from the Hatley-Ascot line and on the east side of this road, a shaft has been sunk within similar chlorite schists traversed by quartz stringers. The strike of the schists is approximately N. 60° E. dipping 70° toward the southeast. To the east of the shaft, a dyke of quartz porphyry, now schistose, intersects the chlorite schists. On a slope corresponding to the dip of the schists the shaft is reported to have a depth of about 30 feet. Fine grains of pyrite are sparsely scattered within some of the quartz veinlets, and in some narrow bands of the schist; within the latter a few particles of micaceous hematite are also present.

About 100 yards from the Hatley-Ascot line and 60 yards to the east of this road a trench, two to four feet in depth, was excavated transverse to the schistosity of barren chlorite and sericite schists.

Two years ago, upon the southern portion of the eastern quarter of this lot, a large boulder of nearly solid sulphide ore (21 in. x 16 in. x 10 in. in maximum dimensions) was discovered partially buried in the soil. A narrow shallow trench was excavated to bedrock and, about forty feet northwest of where the boulder was found, a shaft was sunk upon a band of ferrodolomite-bearing sericite schists containing disseminated grains of pyrite. The schists strike approximately N. 60° E, dipping 45° to the southeast. When the shaft reached a depth on the slope of 28 feet, a cross-cut was driven for eighteen feet toward the southeast. Although this cross-cut would have to be extended five or six feet before it would come beneath the point where the boulder was found, a study of adjacent rock exposures shows plainly that such effort would receive no reward. The boulder is chiefly composed of granular pyrite, chalcopyrite, galena and a little zinc blende and is identical in character with the more solid phases of the ore of the Silver Star or the Howard mines, especially the former. Moreover, attached to one side of the boulder is a thin film of rock similar to the footwall of

The Ives mine, Range IX, lot 2, Bolton township.

Lenticular body of jasper-like quartz, at "Smith's Iron mine," Range VI, lot 2, Ascot township.

these mines. The belief of the writer that this boulder was transported by glacial ice from the vicinity of these mines to the position where it was found, receives also some corroboration in that a few observations of glacial striae indicate that the ice-sheet moved S. 10° to 15° E. within this portion of the district.

The Johnson Mine—Range III, Lot 27, Hatley.—"Yellow sulphurets in a gangue of calcspar in chlorite slate; two trial shafts have been sunk to the depths of 12 and 18 feet respectively."—(G.S.C., 1866, p. 305.)

A symbol indicating the presence of copper upon this lot appears on the Mining Map of Ascot Township, published in 1908 by J. Obalski, then the Superintendent of Mines of Quebec.

This "mine" is mentioned in the "Partial List of Copper and Sulphur Properties in the Eastern Townships," published in 1902 by J. R. Woodward of Sherbrooke.

Within a few yards of each other, the two shafts, referred to above, are situated in the northwestern quarter of this lot, about 70 yards east of the road. Partially filled up, one of these shafts is now about ten feet deep, while the location of the other is marked by a grass-covered depression into which some large boulders have been rolled. The shafts penetrate chlorite schists traversed, parallel to their schistosity, by a few irregular veinlets of quartz. A few small patches of rust appearing upon the surface of adjacent rock outcrops indicate the presence of disseminated grains of pyrite. Examination of the fragments of rock taken from the shaft show that a few scattered grains of pyrite occur within some of the schist and quartz stringers; one or two particles of copper pyrites were also observed to be present.

A few hundred yards further eastward upon this lot, irregular dykes of quartz-porphyry, now altered to sericite schists, are plainly intrusive into the chlorite schists, the metamorphic equivalents of either a fine-grained diorite or a diabase. Southward, a blast has been discharged in a rock outcrop where a band of chlorite schists, less than a foot in width, has been partially replaced by magnetite.

Range IV, Lot 25, Hatley.—"Green carbonate in flakes in white quartz in mica slate."—(G.S.C., 1866, p. 305.)

Upon the northeastern quarter of this lot, about seventy-five yards from its northern boundary, an opening, four to five feet in depth, has been made in chlorite schists, traversed parallel to their schistosity by a few stringers of quartz. A few small grains of pyrite occur within the quartz veinlets and also some of the schist.

The Fish Mine—Range IV, Lot 26, Hatley.—This "mine" is mentioned in the "Partial List of Copper and Sulphur Properties in the Eastern Townships," published in 1902, by J. R. Woodward of Sherbrooke.

Upon the western portion of the eastern half of this lot and near its northern boundary, three openings have been made. Here the schists strike approximately north and south and dip about 45° to the east. One of these openings, now partially filled up with rocks, probably reached a depth of ten feet in ferrodolomite-bearing schists. On the northern wall of this shaft a quartz veinlet, two inches in width, contains a little chalcopyrite and pyrite to a depth of three feet from the surface. To a similar depth, the schists, adjacent to this veinlet and for a total width of about eight inches, contain a few scattered grains of these sulphides. Stains of azurite and malachite have developed upon that portion of this wall immediately below where the chalcopyrite is present. Elsewhere within the shaft, only a few sparsely distributed grains of pyrite were found.

A short distance west of this shaft, a small opening, the result of one or two blasts, has been made in sericite schists which, for a width of four feet, contain sufficient pyrite in the form of small scattered grains and crystals to cause them to appear rusty upon weathered surfaces. Very little pyrite is necessary to produce this appearance, and as one traces the schists, for a few feet, in the direction of their strike, the rusty colours disappear.

Southward from this opening a shaft, now filled up with rocks, probably reached a depth of ten or eleven feet in sericite schists, traversed, parallel to their schistosity, by a few quartz stringers. Upon the northern wall of the shaft, no sulphides are present; upon the southern wall, a small quartz vein and the schist, for a few inches on either side of it, contain scattered grains of pyrite. Here a few particles of copper pyrites were also observed.

At these points on this lot, the indications do not justify that prospecting work be renewed.

The Shannon Mine—Range IV, Lot 27, Hatley.—This "mine" is mentioned in the "Partial List of Copper and Sulphur Properties in the Eastern Townships," published in 1902, by J. R. Woodward of Sherbrooke.

On the northeastern quarter of this lot, at a point about 200 yards from the main road, a shaft was sunk in sericite schists traversed by a few stringers of quartz. An irregular band of these schists, that does not exceed two feet in width, contains a small amount of pyrite in the form of scattered grains and small crystals. Now partially filled with rubbish, the shaft probably did not exceed ten feet in depth. As a prospect, it is of no value.

"*Parnell Copper Mine*," *Range VI, Lot 10, Hatley.*—"The most southerly deposit of copper ore in this direction is near the upper end of Massawippi Lake, on the west side, on lot nine, range six. At this place there appears to be two kinds of rock, the soft blackish and bluish pyritous slates being in contact with the hard quartzo-feldspathic rocks of the mountain series. The contact is probably along a line of fault, and the ore, which is scattered through a width of eight to ten feet, is in the form of the yellow sulphuret, but the shaft being filled with water, the quantity could not be ascertained; a large amount of iron pyrite appears to be mixed with the copper ore. This is the Parnell mine."—(R. W. Ells in G.S.C., Vol. IV, 1888-89, p. 49k; also in G.S.C., Bulletin on Copper, 1904, p. 45.)

Apparently this prospect is on lot 10, instead of on lot 9 as stated in the above quotation. Towards the eastern end of lot 10, one descends from high land, underlain by the complex of more or less schistose representatives of fine-grained igneous rocks, to lower slopes, underlain by dark slaty rocks, formerly of sedimentary origin. The latter rocks are in contact with the former along what is apparently a fault, striking toward the northeast with downthrow to the southeast. A shaft has been sunk on the fault, displaying a light gray felsitic phase of the quartz-porphyry in contact with the dark slaty rock. In thin section under the microscope, the former rock is found to consist chiefly of orthoclase, and a little plagioclase with some quartz and chlorite. Through the action of pressure, the rock has been crushed and granulated and abundant small planes of shearing have been developed within it. Along the shearing planes, chlorite and small amounts of pyrrhotite and pyrite are present; the sulphides appearing in the form of scattered grains or minute veinlets. Hydrated iron oxide, resulting from the oxidation of the sulphides, stains the grains of the rock, thus imparting to it a yellowish rusty appearance. The pyrrhotite is more abundant than the pyrite, while very rarely a particle of chalcopyrite may be found. The shaft has been partially filled with rocks. Its depth was not ascertained, but it probably did not exceed twenty-five feet. Indications do not warrant the revival of prospecting operations in the vicinity of the shaft.

Ascot Township.

The Moulton Hill Mine, Range III, Lot 23, Ascot.—"In the area north of the St. Francis, deposits of ore occur, precisely similar to that of Capelton, and in similar rocks. What has proved to be a very valuable deposit was found about three years ago by Mr. Burke, the owner of the land on lots 23 and 24 of the third range of Ascot, which has since been somewhat extensively developed and purchased by the same syndicate which acquired the Cillis mine. The bed of ore which dips with the slate south-easterly at an angle of 45° to 50° was found to rapidly increase from four to six feet at the surface to a reported thickness of not far from fifty feet, at a depth of seventy feet, revealing an enormous body of ore. This location was revealed by the uprooting of a tree, and is in direct course of the Capelton deposit, which it so much resembles."—(R. W. Ells in G.S.C., Vol. IV, 1888-89, pp. 55k—56k; also in G.S.C. Bulletin on Copper 1904, p. 52.)

"Two new copper mines in the Sherbrooke belt of schists, the Moulton Hill and the Howard have been opened and are now shipping ore to a considerable extent. The ore is very similar to that found at the Capelton mines, and, like that, is used for the manufacture of sulphuric acid. The copper contents of the lode apparently increase as the veins or lodes are opened downward,"—(G.S. C., Vol. V, 1890—91, p. 46A.)

"The Moulton Hill and the Howard mines have been opened up in the last year, and the work has been mainly development. At the Howard mine, shafts have been sunk, and cross-cuts made to a depth of some 200 feet, and a large amount of ore opened out which will be broken when the developments are sufficiently advanced.

At the Moulton Hill mine about the same amount of work has been done, and in addition a plant has been erected, calculated for raising, dressing and shipping from 100 to 200 tons of ore daily. The ore-ground is as yet not broken except incidentally in the shafts and drifts. The shipments of the company to date from ore incidentally met with amounts to some 2000 tons."—(Canadian Mining Review, April, 1890.)

In the report of the G.S.C., Vol. V, 1891, p. 67ss, it is stated that at the Moulton Hill mine "the work was largely of a development nature."

In the report of the G.S.C., Vol. VI, 1892—3, p. 58s, it is stated that "The Moulton Hill and Howard Mines Company were engaged mostly in developing their mines."

"The Moulton Hill mine is temporarily closed."—(The Canadian Mining Review, Dec., 1892.)

In the report of the G.S.C., Vol. VII, 1894, p. 50s, the statement appears that—"The Moulton Hill mine was temporarily shut down, but they operated their Howard mine, shipping the ore in the raw state to their works at Cleveland, Ohio."

"The Moulton Hill mine, a few miles east of Sherbrooke, was worked at the same time as the Howard and under the same management. It seems to have produced about a thousand tons of ore per month during the last year it was in operation."—("Copper Deposits of the Eastern Townships," by J. A. Dresser, G.S.C., 1907, Publication No. 975, p. 6.)

"This property is located on lots 23 and 24, range III, township of Ascot. The surrounding country is well covered with soil and prospecting in the neighbourhood would have to be done by drilling. The original discovery is said to have been made by the uprooting of a tree. The country rock is a sericitic schist carrying quartz veins and stringers and a good deal of pyrite. The ore body which lay approximately with the rock structures, dipped in a southeasterly direction at an angle of about 50°. The reported thickness is said to have been between 4 and 6 feet at the surface. At a depth of 70 feet, it is said to have had a width of nearly 50 feet. The mining operations appear to have been carried out through a three compartment shaft 6′ x 15′ in section, inclined parallel to the dip of the ore body. There is also a small vertical shaft on the property. Both shafts are caved; the mine is full of water, and no data could be obtained as to the extent of the underground workings. The ore was apparently a mixture of pyrite and chalcopyrite, the former predominating. The mining operations were carried on by the same United States company that operated the Howard mine, and the ore was shipped to the United States for use in acid works. It has been stated that during the last year of its operation the production reached about 1000 tons per month. No further data are now available."—("Pyrites in Canada," by A. W. G. Wilson, Mines Branch Publication, No. 167, 1912, p. 58.)

In 1889, this mine was opened up by the Grasselli Company of Cleveland, Ohio, and, including periods of extended operation as well as those in which operations were temporarily suspended, was worked until 1895. The shaft is situated close to the northern boundary and just west of the middle of the lot, at the contact between dark chlorite schists and light grey sericite schists, striking to the north-east and dipping 40° to 45° toward the south-east. In their petrographical character, the latter are identical with the sericite schists of the Eustis, Suffield and some other mines of the district, and, like them, are the metamorphosed equivalents of quartz porphyry. Here the sericite schists pass gradually into chlorite schists within which numerous original phenocrysts of quartz are yet visible; the relationship between these and other darker, more basic chlorite schists, within which no quartz is present, could not be determined because of scarcity of rock exposures. On the adjacent lot 24, not more than two hundred yards removed from the shaft, there is an exposure of the quartz porphyry where it is less schistose and so coarsely crystallized that it appropriately might be called granite porphyry. Much of the chlorite and the sericite schists, but especially the former, are impregnated with abundantly scattered grains of pyrite and of a brown ferrodolomite, the cleavage faces of the latter often being found one-fourth to half an inch across.

According to W. Jenkins, formerly manager of this mine and now of the Suffield mine, the shaft descends on a slope of about 45° to a depth of about 70 feet and then with a dip that rapidly flattens out, extends to about 200 feet on the slope. The deepest point in the mine, according to him, is somewhat more than 300 feet on the slope, this depth being reached by a winze. Some faults were encountered. The upper workings were in an irregular body of practically solid pyrite, that rapidly increased in thickness from four to six feet at the surface to a maximum of between forty and fifty feet; with depth they passed into schists more or less impregnated with pyrite. When the disseminated ore completely took the place of the solid ore, they searched for a continuation of the latter type, and as a result, there is a considerable network of drifts, crosscuts, etc. Large stopes, that come very close to the surface, were developed during the removal of the solid ore and while a persistent attempt was made to profitably concentrate the low grade ore. A mill was erected, a crusher, Wilfley tables, etc., installed, and a considerable tonnage of the best of the low grade ore was concentrated. A tramway was constructed from the mine to the Quebec Central Railway, a distance of approximately two-thirds of a mile.

The information that could be gathered concerning the underground workings would suggest either that the continuation of the solid ore has been obscured by faulting, or that an irregularly lenticular body of pyrite would have developed if replacement of the schist had been more complete. According to this latter suggestion, owing to incomplete replacement, only the upper portion of the body has been converted to nearly solid pyrite. Owing to the covering of drift that blankets the vicinity, any further prospecting, if attempted, should be done with a drill.

To-day quite large dumps bear tribute to the extent of the underground workings. The main shaft has caved in, as well as the small prospect shaft situated a few yards to the northward. The mill has disappeared and only traces of the former existence of the tramway remain. No underground plans of the mine or records of the tonnage of ore produced are now available.

Examination under the microscope of a thin section of a specimen of what would be called solid ore, which was selected from the dump, was found to be composed of two-thirds of pyrite in a matrix of an iron-bearing carbonate with very little quartz and a few small flakes of sericite. The pyrite, in large part, displays more or less definite crystal outlines.

Upon a careful search of the dump, a few specimens may be found in which mere traces of the presence of copper may be seen. Nevertheless, although as may be observed in the preceding quotations from various reports, the Moulton Hill mine has been referred to repeatedly as one of the copper mines of the district, *it has never produced any copper.* The pyrite from this mine was shipped to the works of the Grasselli Chemical Company in Cleveland, Ohio, where it was used in the manufacture of sulphuric acid, etc.

To T. J. Grasselli, of the Company that operated this property I am indebted for the following memorandum:—"The Moulton Hill mine opened up in a large deposit of iron pyrites running about 45 per cent of sulphur with neither copper nor silver, and at a depth of about 60 to 75 feet went into disseminated material, which rendered it unprofitable to use."

The McDonald Mine, Range III, Lot 24, Ascot.*—Under this name this "mine" is mentioned in the "Partial List of Copper and Sulphur Properties in the Eastern Townships," published in 1902, by J. R. Woodward of Sherbrooke.

The mining rights of this lot were taken up, because the Moulton Hill mine is situated quite close to its southern boundary and it was thought possible that with depth the ore-body might pass across the line. Mr. John McDonald of Sherbrooke informed me that no minerals of value have been found in rock exposures and no openings have been made upon this lot.

Old Moulton Hill Mine, Range IV, Lot 15, W½, Ascot.—"More highly argentiferous galena has been found in small quantities in quartz veins, as at the rapids of St. Francis on the Chaudière and at Moulton Hill near Lennoxville; in both cases with mispickel."—(G.S.C., 1863, p. 516.)

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*This must not be confused with the McDonald or Weedon mine on range II, lot 22, Weedon, that was discovered by Mr. John McDonald.

"The galena from Moulton Hill, mentioned above, was much mixed with mispickel, even in selected specimens. A portion of the crushed and washed ore gave by assay twenty-eight per cent of lead; and this contained one part in 500 of silver, equal to sixty-five ounces to the ton of lead."—(G.S.C., 1863, p. 518.)

"Another locality is at Moulton Hill, on the fifteenth lot of the fourth range of Ascot. Here a vein of white quartz, about four and a half feet wide occurs in a black shale, which is also traversed by numerous small seams of quartz. The galena is here, as at Vaudreuil, associated with mispickel. It is too sparingly distributed in the vein to be of importance as an ore of lead, although it may perhaps be wrought for the silver of which it contains a considerable portion."—(G.S.C., 1863, p. 691.)

The writer has seen this property listed among the copper mines of Ascot; in reality no copper-bearing minerals occur within the quartz. Considerable work has been done here. Judging from the amount of barren quartz in the vicinity of the shaft, and also from the statement of Mr. John McCaw, whose father was interested in this property, the mining venture proved to be a distinct failure. The quartz veins traverse slates, parallel to their northeasterly strike. Within portions of these veins, scattered grains of mispickel, galena and pyrite are present. The shaft has been utilized for the burial of five or six horses.

Range IV, Lot 17, Ascot.—Upon this lot, not far from its western boundary, an opening six feet in depth has been made in chlorite schists, traversed by a few quartz veins, up to three inches in width. These quartz stringers and certain narrow bands of the schist contain a few scattered grains of pyrite.

The Boudreau Mine, Range IV, Lot 24, Ascot.—During the past two or three years, prospecting work has been carried on upon this lot. Within a few yards of the road leading to Ascot Corner, a shaft has been sunk in sericite schists, the metamorphic equivalent of quartz porphyry of a type that very frequently occurs in the Stoke range. These schists strike N 15° E, dipping 35° to 40° toward the southeast. In May, 1915, the shaft had reached a depth of 120 feet and work was progressing. A band of the schists within which the schistose structure is more intense than usual and the weathered surface is rusty, may be traced for about ninety feet along the strike with a maximum width of about seventeen feet. As is usual within the district, the rusty appearance indicates the presence of disseminated grains of pyrite within the schists. For a width of six or seven feet, the grains of pyrite, together with a very few widely scattered grains of chalcopyrite and zinc blende, comprise about one-tenth of the volume. The shaft, 9 ft. x 12 ft., descends upon this portion of the band, following the dip, which at first is 35° and towards the bottom increases to 40° because the schists roll somewhat. The footwall is a slightly more massive band of the same schistose quartz porphyry as that which through shearing has been rendered more fissile and is now partially replaced by the pyrite. Near the footwall, a band of the schist, that varies from a few inches to a foot and a half in width, is characterized by the presence of a slightly higher percentage of pyrite and the relatively more frequent occurrence of grains of chalcopyrite and zinc blende. Apart from the variations in the width of this narrow band, the mineralization of the schists, both in amount and character, is the same as at the surface. Although portions of the schist from this band are sufficiently mineralized to suggest the application of concentrating methods, very little, if any, encouragement can be offered that further work will disclose a body of such ore of a size adequate to constitute a commercial enterprise.

Range V, Lot 17, Ascot.—"Yellow sulphuret with iron pyrites in mica slate."—(G.S.C., 1866, p. 306.)

Symbols indicating the presence of copper upon this lot appear both on the geological map (Sherbrooke Sheet) of the Eastern Townships, accompanying Part J, Vol. VII, 1894, G.S.C., and on "The Mining Map of Ascot Township," published in 1908 by J. Obalski, then the Superintendent of the Department of Mines.

In the northwestern portion of the eastern half of this lot two openings, each of which reached a depth of about eight feet, were made in sericite schists, striking N. 65° E. and dipping about 35° to the southeast. The schists are traversed, parallel to their schistosity, by a few narrow quartz stringers; both in the quartz and in the schists, a few scattered grains of pyrite are present.

The story is told that attention was attracted to this property by certain unprincipled individuals who carried some fragments of ore from Capelton, concealed them in some bushes on this lot and later "made a discovery."

Range V, Lots 18 and 19, Ascot.—The eastern half of each of these lots is owned by an elderly gentleman, a Mr. Armstrong, who, when younger, devoted much time and labour to a search for both copper and gold upon his farm. Upon the eastern half of lot 18, four shafts have been sunk. One of these, near the southeastern corner of the lot, is nine feet in depth; another, near the middle of the eastern boundary of the lot, is twelve feet in depth; two others, only a few yards apart and close to the south boundary, are each about eleven feet deep. All of these openings penetrate sericite schists containing scattered grains of an iron bearing carbonate and of pyrite. Within the two shafts "close to the southern boundary" a very few particles of copper pyrites are also present in the schist. This work has disclosed nothing of value.

On the eastern half of lot 19, five shafts have been sunk to depths of from nine to twelve feet with the hope of discovering gold in irregular quartz veins traversing schists and slates, the metamorphosed equivalents of argillaceous sedimentary rocks. Two of these shafts, near the centre of this half of the lot, have attracted considerable attention. For a width of about fifty feet the slates enclose numerous quartz veins that pinch and swell in a very irregular manner; yet these veins comprise about one half of this width. In general the quartz is barren but, in some portions of these veins, grains and crystals of pyrite are very irregularly distributed. Within one of these shafts, from five to six feet of quartz contain considerable disseminated pyrite. An assay for gold of specimens of rusty quartz containing pyrite from this shaft yielded $2.20 of gold per ton. Indications do not warrant the renewal of prospecting work in this locality.

The Nutter or the Dufort Mine, Range V, Lot 20, N.W. ¼, Ascot.—"Yellow sulphuret in chloritic slate."—(G.S.C., 1866, p. 306.)

Under the name of the "Dufort" mine it appears on the Mining Map of Ascot Township, published in 1908, by J. Obalski, at that time the Superintendent of Mines of Quebec.

A symbol indicating the presence of copper upon this lot appears on the geological map of the Eastern Townships accompanying Part J, Vol. VII, of the G.S.C.

In the "Partial List of Copper and Sulphur Properties in the Eastern Townships, P.Q., and from which sufficient ore has been guaranteed to meet Capacity of Custom Smelter and Chemical Works" published in 1902 by J. R. Woodward of Sherbrooke, it is stated, "Work has also been done during 1901 on the Nutter property. This property is situated in Ascot, within a mile of the city of Sherbrooke. Considerable development work has been done. Assays show gold, silver and copper, the latter running 12%. If smelter established, 10 tons per day promised."

Within a distance of approximately fifty feet, three shafts or openings have been sunk along an irregular rusty band of chlorite schists, up to about two feet in width, that are traversed by a few veinlets of quartz. Small grains of pyrite occur within the schists and in portions of the quartz stringers. Most careful examination revealed the presence of a few widely scattered particles of copper pyrites. Owing to local contortion of the schists which has caused them to be at variance with the regional north-easterly trend, the schists here strike N. 55° W. and dip 50° to 60° to the northeast. Partially filled with rubbish two of the shafts, 30 feet apart, must have each attained a depth of about 18 or 20 feet, while, a few feet removed, the third opening is 8 to 10 feet deep. It is ridiculous to consider these openings as a possible economic source of copper; the amount of pyrite present is also negligible.

Range VI, Lot 16, Ascot.—"Yellow sulphuret in chloritic slate."—(G.S.C., 1866, p. 306.)

Symbols indicating the presence of copper upon this lot appear both upon the geological map (Sherbrooke Sheet) of the Eastern Townships that accompanies Part J, Vol. VII, 1894, G.S.C., and on the "Mining Map of Ascot" published in 1908 by J. Obalski, then Superintendent of the Department of Mines of Quebec.

Near the western boundary of this half lot and twenty yards to the south of the road, a few blasts have been discharged in the face of a steep exposure of fine grained diorite that displays a tendency to schistosity, striking N. 55° E. and dipping steeply to the southeast. The rock is traversed by a few veinlets of quartz and calcite. If either pyrite or chalcopyrite occurred in the rock where these blasts were fired, the writer was unfortunate in not being able to find it. Nearer the road on the same outcrop a rusty patch, 3 ft. x 2 ft. in maximum dimensions, indicates the local presence of a few disseminated grains of iron pyrites.

About forty yards to the north of the road a hole was dug to a depth, it is said, of 20 feet in a vain attempt "to find water."

Archambault Mine, Range VI, Lot 19, Ascot.—Copper also occurs in veins of quartz in several places on the nineteenth and twentieth lots of the sixth range of Ascot.—(G.S.C., 1863, p. 733.)

This "mine" is mentioned in the "Partial List of Copper and Sulphur Properties in the Eastern Townships" published in 1902, by J. R. Woodward of Sherbrooke.

On the "Mining Map of Ascot Township," published in 1908, by J. Obalski, then the Superintendent of Mines of Quebec, the *Bowen* and *Vezina* mines are located upon this lot.

On the western half of this lot, to the north of the road that passes across it to Ascot Corner, considerable work has been done at different times. Near its northern boundary, on that portion of the lot now occupied by a Mr. Blanchard, two shafts were sunk in chlorite schists traversed, parallel to their schistosity, by quartz stringers. One of these, known as the Archambault mine, was sunk more than thirty years ago, to a depth on the slope of about 40 feet. Two years ago the water was taken out of the shaft by Mr. H. Astbury, who states that at the bottom a band of the schists, up to about eighteen inches wide, contains disseminated grains of pyrite.

About 150 yards southward, Mr. H. Astbury, two or three years ago, sank a shaft in similar schists to a depth of twelve feet. Judging from fragments on the dump, some of the schist carries scattered grains of pyrite, one band of the schist, up to four inches in width, being quite thoroughly impregnated with this mineral; a few particles of copper pyrites are also present.

About thirty yards west of Archambault's shaft, Mr. H. Vézina made an opening, about twelve feet deep, in similar chlorite schists, striking nearly north and south and dipping 30° to the east. Within the shaft one of the irregular quartz veins that traverse these schists, parallel to the schistosity, must have attained a width of seventeen inches. A few widely scattered grains of pyrite are present in the quartz veins and in narrow bands of the schist.

Eastward from Archambault's, another shaft was sunk which probably did not exceed twenty feet in depth. Fragments on the dump show that some of the schist carries a few grains of pyrite.

No ore was shipped from this lot. The indications do not justify the continuation of prospecting operations.

The Griffith Mine, Range VI, Lot 20, Ascot.—The presence of copper pyrites is reported in quartz veins in several places on the nineteenth and twentieth lots of the sixth range.—(G.S.C., 1863, p. 733.)

"Yellow sulphuret in chloritic slate."—(G.S.C., 1866, p. 306.)

Symbols indicating the presence of copper upon this lot appear both on the geological map of the Eastern Townships (the Sherbrooke Sheet) that accompanies G.S.C. Part J, Vol. II., 1887, and on the "Mining Map of Ascot Township," published in 1908, by J. Obalski, then the Superintendent of the Bureau of Mines of Quebec; upon the latter it appears under the name of the Griffith.

This lot is mentioned in the "Partial List of Copper and Sulphur Properties in the Eastern Townships," published in 1902, by J. R. Woodward of Sherbrooke, as one upon which considerable work has been done.

Towards the middle of the western half of this lot, a few blasts have been discharged in the face of a steep exposure, about 12 feet in height, of a fine grained diorite displaying a tendency to schistosity and traversed by a few irregular stringers of quartz. The most continuous of these quartz veins is four to five inches in width. Druses within this vein contain small clear crystals of quartz. The quartz stringers and to a small extent the rock adjacent to them are somewhat rusty upon exposed surfaces because of the presence of irregularly scattered grains of pyrite. Only one or two particles of copper pyrites were observed within one of the quartz veins.

Towards the southern boundary of the western half of this lot, a few blasts have been discharged in outcrops of chlorite schist and some trenching to bed-rock has been done.

The Smith Iron Mine, Range VI, Lot 21, Ascot.—This property is first referred to in the G.S.C. report of 1847-48, p. 87, under the heading of Jasper, as follows:—"A bed of rock of this colour was met with at Sherbrooke; in some parts it was about six feet thick, and it was traceable with the stratification for some distance, passing occasionally into a jaspery iron ore and showing lines and spots of specular iron. At the surface it is not very sound, being apparently in a slight degree disintegrated by exposure to atmospheric action, and its texture does not seem to be quite so compact as jasper of the best quality. It is probable, however, that some parts of it, free from atmospheric injury, might be fit for ornamental articles."

"A deposit of magnetite, owned by Mr. Stephen Smith and others of Sherbrooke, occurs with a hard jaspery rock and schist, three-fourths of a mile from the Grand Trunk Railway. The vein is apparently of large size and the ore of good quality. About 500 tons of ore have been taken from the outcrop, but though the lack of cheap fuel has prevented its profitable smelting on the spot, the quality and value of the ore and its accessibility are such that a good market should be obtained for a large figure at paying quantities in the neighbouring states." (G.S.C., 1885, p. 53a.)

"Deposits of magnetite of considerable extent are known to exist at several points, principally in what is regarded as the lowest series of rocks. Of these, apparently one of the most important is seen in the immediate vicinity of Sherbrooke, on lot 21, range VI, Ascot, on property owned by Mr. Stephen Smith. The vein, which is from ten to fourteen feet wide, occurs in hard chloritic and feldspathic schists, associated with quartz and jasper. The ore, of which about 500 tons have been extracted, is slightly calcareous and of excellent quality. Assays of the ore, recently made by Mr. Hoffman, gave 54.074 per cent of metallic iron." (R. W. Ells in G.S.C., 1886, p. 60j.)

"Adjoining and opposite the city of Sherbrooke, on lot 21, range six, Ascot, about three-quarters of a mile from the Grand Trunk Railway station, on the property of Mr. Stephen Smith, is another apparently large deposit of magnetic ore. The containing rocks here are for the most part chloritic schists of the Sherbrooke anticlinal, along with jasper which was referred to in the earlier reports of the Geological Survey. Precisely similar rocks are found in the city of Sherbrooke itself and on the road south to Capelton near the fork of the road to Belvidere. The thickness of the ore and its extent on Mr. Smith's lot are unknown, but it is evidently quite extensive and a considerable quantity of ore has been extracted. An analysis by Mr. Hoffman gave:—Metallic iron, 54.07; Phosphorus, .660; Sulphur, .024 with no trace of titanium." (R. W. Ells in G.S.C., 1888-89, p. 20k.)

On the geological map of the Eastern Townships (the Sherbrooke Sheet) accompanying G.S.C. Part J, Vol. II, 1887, a symbol indicates the presence of copper on this lot in the position occupied by the "iron mine", while upon the adjacent lot (range VII, lot 21) a symbol representing the presence of iron appears.

This lot is mentioned in the "Partial List of Copper and Sulphur Properties in the Eastern Townships" by J. R. Woodward of Sherbrooke, in 1902, as one upon which "considerable work has been done."

This prospect is situated near the northwestern corner of the eastern half of lot 21, range VI. Here, within fifty yards of each other, two large lenticular bodies of quartz are enclosed within chlorite schists, striking approximately N. 22° E. and dipping quite steeply toward the southeast. One of these quartz masses is ninety feet in length with a maximum width of fifteen feet; the other, though not completely exposed, is at least one hundred and ninety feet in length with a maximum width of about sixty feet. Each of these masses is composed chiefly of bluish to grayish granular quartz that locally passes gradually into a jasper of poor quality; both are traversed by irregular stringers of milky quartz containing a few flakes of micaceous hematite. (See Plate VII.)

The larger of these lenticular bodies contains some contorted ribbons and bands of the chlorite schist that have been partially replaced by magnetite. Such bands of schist, now more or less replaced by magnetite, are not of constant width and are in part interbanded with the jasperoid quartz. It is upon the widest of these bands of schist, varying from three to fourteen feet across, that occupies a position somewhat transverse to the lens, that about thirty years ago a shaft was sunk. Although specimens may be selected in which the iron content is quite high, as shown in the analysis mentioned in the older reports, the deposit as a whole is so very low in grade and of such small dimensions that it cannot be worked profitably. The shaft probably is 100 feet or more in depth; much rubbish has been thrown into it.

About seventy yards eastward from the above shaft, an opening has been made which originally was probably about ten feet deep in chlorite-sericite schists containing disseminated grains of ferrodolomite and of pyrite.

The Clark Mine.—Range VII, Lot 11.—"Here a bed of copper-bearing slates of considerable thickness was discovered, and operations have been vigorously carried on for the last year, and large quantities of ore have been taken out and sent to market. Of the approximate quantity of ore extracted or its copper contents, I am not aware." ("Copper Mining in Canada East," by Herbert Williams, Quebec Lit. and Hist. Soc., 1865, p. 49.)

"Yellow sulphuret in chloritic slates. The ore appears to occur in large irregular patches parallel to one another, probably resulting from undulations in one or more beds. As extracted, it may contain about 3½ per cent of copper, and large quantities of it, obtained chiefly in open cuttings, have been dressed and sent to market. Two shafts have been sunk, one of them 60 feet deep, and an adit driven 200 feet. Machinery and buildings for crushing and dressing have been erected. This is the Clark Mine. It has been operated by an American Company, but operations are for the present suspended." (G.S.C., 1866, p. 306.)

This property is mentioned by Ells as one of "thirteen mines" that "were operated" in Ascot prior to 1865. G.S.C., Vol. IV, 1888-89, p. 50k. In this report, on pages 51k to 52k, he also writes—"The Clark mine is situated one mile and a half from Lennoxville station, G.T.R., on lot 11, range VII, Ascot. This was first opened in 1863 by Mr. Wm. Clarke, and was worked with more or less vigor for several years, principally by an American Company, who took out a large quantity of ore. The work was carried on for the most part by open cuttings upon a vein said to have a thickness of eighteen feet, (?) and containing three and a half per cent metallic copper. This estimated thickness of ore is, however, doubtless exaggerated, since, on the most reliable authority, the thickness never exceeded seven to eight feet, and gradually decreased to eighteen inches. In addition to surface workings a pit was sunk to a depth of forty feet, and a shaft for 73 feet. Further explorations were carried on in 1866, but without success, and in that year, the mine was sold at sheriff's sale. No returns as to quantity or quality of output are to hand, and the mine has apparently remained idle since the date mentioned."—(Also appears in G.S.C. Bulletin on Copper, 1904, pp. 47–48.)

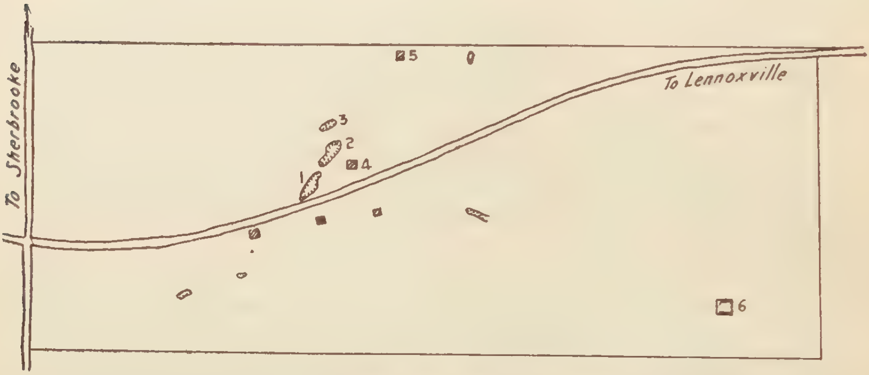

Fig. 7—Surface plan to show approximate position of workings at the Clark mine, lot 11, Range VII, Ascot.

Very little further information was gathered concerning this property. From 1863 to 1866, much work was done and a crusher and concentrator (formerly stood at 6, in Sketch) erected to handle the ore. At that time, copper varied in price from 26½ to 55 cents a pound in the United States, labour was cheap and as to-day, the Grand Trunk Railway was at Lennoxville; yet, the property was operated at a heavy loss to the owners. The accompanying rough sketch shows the approximate distribution of openings made upon this lot. The appearance of the shaft near the northern boundary of the lot (No. 5 in sketch) and of one or two of the smaller openings to the south of the Lennoxville road, suggest that they belong to relatively more recent attempts in the prospecting of the property, but it is claimed that the three comparatively large open cuts and the deep shaft immediately north of this road have not had the water removed from them since the early days of working.

The lot is underlain by schistose rocks, chiefly chlorite and sericite schists, striking N. 40° to 50° E. and dipping from 30° to 50° to the southeast. The schists of the eastern and southeastern portions of the lot are metamorphic equivalents of argillaceous sediments cut by small bodies of intrusive porphyrites and allied rocks; the western and northwestern by the metamorphosed equivalents of quartz-porphyry, and porphyrites with their allied rocks, the former probably being intrusive into the latter.

Nearly all of the openings were made in the western half of the lot, the most of them in sericite schists and chlorite-sericite schists, the highly altered equivalents of quartz-porphyry. Here, along bands of irregular width, frequently up to several feet across, exposures of these schists weather with a very rusty appearance because they are impregnated with finely disseminated pyrite in which one may rarely see a trace of copper. The schists are traversed, parallel to their schistosity by a few narrow stringers of quartz and ankerite, occasionally carrying scattered grains of pyrite, sometimes with a little chalcopyrite.

Open cut, No. 1 in sketch, is about 150 feet in length along the strike, forty feet wide, and toward the southwestern end is said to have reached a maximum depth of about forty feet on a slope of about 35° toward the southeast. Most of the ore taken from the property is said to have been from this pit, where work progressed upon a lenticular vein of pyrite carrying a small amount of copper. Mr. John Smith, who lives on lot 11, range VIII, and who, in the early days, worked for a time in this pit informed me that the vein possessing a width of seven or eight feet narrowed with depth, but it is his claim that near the southwestern end of the pit a portion of the vein with its original width, to-day dips beneath the Lennoxville road. According to him, open cuts, Nos. 2 and 3 in sketch are not as deep as No. 1; in No. 2, a zone of the schists, "about six feet in width," enclosed numerous quartz stringers carrying some chalcopyrite. No. 4 in sketch is the shaft that Ells states to be 73 feet in depth. It is said that nothing of value was discovered in this shaft, or in open cut No. 3.

No. 5, in sketch, is a shaft, ten or twelve yards from the northern boundary of the lot, and possibly forty feet deep on a slope of about 30° to the southeast. Upon the dump there are some fragments of good granular pyrite ore carrying a very little zinc blende, and a very little chalcopyrite showing that within the shaft, a vein of this material must have attained a width of at least fifteen inches. The ore is identical with that of the Eustis and other similar mines of the district. Some of the sericite schist on the dump also is quite heavily impregnated with pyrite. Evidently, work has been done upon a small lenticular vein of the sulphides mentioned. A few yards from here across the northern boundary of this lot in lot 12, a small opening was made in sericite schists well impregnated with pyrite.

The open cuts or pits and the shafts described above are situated to the north of the Lennoxville road, and are now surrounded by a second growth of bush. The other openings marked on the sketch are either trenches or shafts of comparatively shallow depth that have not revealed any ore of commercial value.

Prospecting with the diamond drill upon this property, as for example in the vicinity of open cut No. 1 or shaft No. 5, possibly might result in the discovery of some workable lenticular vein or veins of pyrite carrying a low percentage of copper. Such prospecting should be done only under financial conditions that will stand negative results.

The Sherbrooke Mine.—Range VII, Lot 12, Ascot.—"Yellow sulphuret in chloritic slate, disseminated to a breadth of eight feet in one band, while others are known to exist on the lot. This is the Sherbrooke mine." (G.S.C., 1866, p. 306.)

It is mentioned as one of the "thirteen mines" that "were operated" in Ascot township prior to 1865 in G.S.C. 1888-89, p. 20k.

"The Sherbrooke mine immediately adjoins that just described, to the south, and is traversed by the same lodes as are found in the Clarke mine. It has been quite extensively explored on the surface, though not yet opened up by underground exploration. Several valuable deposits of pyrites are reported on this property, one of which is said to have a thickness of eight feet, while another was stated to be no less than seventy feet in width (?). Assays by several parties give from $4.00 to $5.00 of gold, $11.00 per ton of silver and from thirty to forty per cent of sulphur." (G.S.C. 1888-89, p. 52k; also in G.S.C. Bulletin on Copper, 1904, p. 48.)

Under this name it appears upon the "Mining Map of Ascot Township," published in 1908 by J. Obalski, then Superintendent of the Bureau of Mines at Quebec.

It is mentioned in the "Partial List of Copper and Sulphur Properties in the Eastern Townships from which Sufficient Ore has been guaranteed to meet Capacity of Proposed Custom Smelter and Chemical Works," published in 1902 by J. R. Woodward of Sherbrooke.

Approximately 450 yards to the east of the road crossing the western portion of this lot and in the northern half of the lot, the original Sherbrooke mine is situated. Apparently, the shaft was sunk at the contact between chlorite and sericite schists, striking approximately N. 70° E. and dipping 45° to 55° toward the south east, the darker chlorite schists forming the hanging-wall. Mr. S. L. Spafford, the Superintendent of the works of the Nichols Chemical Co. at Capelton, kindly furnished the following information:— "The old original Sherbrooke mine was first opened up by the Canadian Copper and Sulphur Co., probably about thirty years ago. In 1907 we did some work at this point, extending the shaft from a depth of eighteen feet to about eighty feet. The vein was well defined, varying from six inches to two feet in width. The ore carried about five per cent of copper, thirty-two per cent of sulphur and low values in silver and gold. The hanging-wall and the foot-wall finally came together so as to cut the vein out almost completely. No drifting was done to determine the size of the vein on either side of the shaft."

It seems plain that, in this shaft, work progressed upon a lenticular vein of small proportions, chiefly composed of pyrite, chalcopyrite and quartz. It is quite probable that sinking this shaft to greater depth and cross-cutting, or by diamond drilling in its vicinity, the presence of other similar small bodies of ore might be revealed. Nevertheless, the present condition of this property does not permit that it be considered as a definite source from which copper ore can surely be derived at a profit. There is nothing on the property that resembles a vein of seventy feet in width, while the values in gold and silver attributed to the ore, (as mentioned in G.S.C., 1888-89, p. 52k and in G.S.C. Bulletin on Copper, p. 48) must be very exceptional.

Toward the southwest from the old Sherbrooke mine, and about 200 yards to the east of the road crossing the western end of this lot, the Nichols Chemical Co., sank another shaft which penetrates chlorite schists, the metamorphic equivalents of a fine-grained diorite or diabase. This shaft is situated within a zone where the schistosity is especially intense. The schists strike approximately N. 80° E. and dip 40° to 50° to the southeast. Judging from fragments on the dump, narrow bands of the schist have been partially replaced by magnetite. Other bands have been so impregnated with pyrite that they are now more than two-thirds composed of this mineral. No copper-bearing minerals were observed to be present. Concerning this opening, Mr. Spafford writes:—"Here the work consisted of sinking a shaft of about 125 feet in depth. The deposit of iron pyrites varied from six inches to about two and a half feet in width. The reason of our discontinuing operations was on account of the smallness of the vein. We did a little drifting on each side of the pit without finding anything of importance."

"The total quantity of ore shipped from both shafts was about 125 tons."

The Capelton Mine (*including the Albert, the Capel or the Walter, the Betsy and other shafts,*)—*Range VIII, Lots 3 and 4, Ascot.*—These mines are on Capelton Hill at elevations of approximately between 400 and 500 feet above the tracks of the Boston and Maine railway. Upon adjacent lots, to the southwest, and, on the same band of sericite schists, the Eustis mine is situated. Since the mode of occurrence, origin and mineralogical character of the ore-bodies of the Capelton mines were identical with those at the Eustis, the majority of the brief references to these mines in literature are associated with the descriptions of the Eustis property. For geological information, the reader is advised to consult the description of the Eustis mine that appears on later pages of this report. At the Capelton mines, the ore-bodies are said to have varied from narrow vein-like bodies to lenticular masses more than fifty feet across. "A considerable portion of the ore carried over five per cent in copper, and on one occasion an ore-body of considerable size, containing over fifteen per cent in copper, was encountered."*

The first discoveries at the Capelton mines were made in 1863. At first they were considered as gold prospects, but exploratory work demonstrated the presence of lenticular bodies of cupriferous pyrite carrying low values in silver and gold. The Capel mine received its name from Mr. George Capel, the original owner of the property, who in company with Messrs. Hunter and Pierce spent from $8,000 to $10,000 in development work. The results of the work proved to be satisfactory, and they decided to divide the property into two portions; the eastern area, under the name of the Albert mine, passed into the hands of Messrs. W. H. A. Davies and others of Montreal who formed the Belvidere Mining Company. In the latter days of 1866, four shafts had been sunk on the Albert property, in one of which, the Albert shaft, at a depth of 121 feet, a cupriferous band possessed a thickness of five feet, of which more than three feet was rich copper ore. At the same time on the Capel property, a vein of cupriferous pyrite, from 3 to 6 feet in width, had been followed for about 300 feet. Soon afterward the property passed into the possession of John Taylor & Sons of London by whom a plant was erected to treat the ore by the Henderson wet process. This process failed to give satisfaction and the mines were closed. At that time, the Albert shaft had reached a depth of 300 feet on an incline of about 30° toward the southeast.

In 1879, the properties passed into the hands of G. H. Nichols & Co., by whom the mines were operated practically continuously until 1907. Since this company assumed control, very little detailed information concerning either the workings or the output of these mines has appeared in literature. For several years the production of ore exceeded that from the Eustis mine. In 1885, 25,000 tons of ore were taken from the property. Early in 1886, two shafts, the "Albert" and the "Wheal Betsy" were being worked; the former was 600 feet, and the latter 200 feet in depth. It is stated that at that time the Albert was working on a body of cupriferous pyrite with a width of fifteen feet. The Betsy, which when 200 feet deep is said to have displayed a vein four feet in width was extended to a depth of 250 feet and was then abandoned. In 1887, while the Company was engaged in the erection of Sulphuric Acid Works at Capelton, there was a decline in the output of the mines. It seems probable that in 1888, about 34,600 tons of ore were produced.

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*"Pyrites in Canada" by Dr. A. W. G. Wilson, Mines Branch, Ottawa, 1912, p. 57.

In 1889, the output was 36,000 tons. A small smelting plant was installed to treat the cinder from the Chemical Works as well as the richest of the copper ore. In 1889, also, works were constructed for the manufacture of chemical fertilizers and during the year 500 tons of Ottawa phosphates were used. The Company was then employing about 300 men and treating about one-sixth of the output from the mines at its Chemical Works, while the remainder of the ore was shipped to various acid works in the United States.

In 1893*, the No. 1 or Albert shaft had reached a depth of 2,100 feet on an incline that averaged about 30° toward the southeast; No. 3 shaft was 400 feet deep, and the No. 4 or Walter shaft was about 700 feet in depth. When one compares the data available concerning the production of the Eustis mine with the figures showing the total production of cupriferous pyrite in the province of Quebec, it is plain that after 1893, the annual output of the Capelton mines was very much reduced from what it had been in previous years. For a few months subsequent to August 17th, 1893, work was suspended. In 1894, the decline in the price of copper caused the Eustis and the Capelton mines to reduce their staff by more than one half. In Mr. Obalski's report for 1897, it is stated that about fifty men were employed underground, twenty on the surface and seventy in Chemical Works. Mining operations ceased in 1907 "because the supply of ore had been exhausted." Mr. S. L. Spafford, the Superintendent of the Nichols Chemical Works at Capelton, informed me that during the three or four years prior to being closed down, these mines (the Albert and the Walter) were producing only about a thousand tons of ore annually. The Albert and Walter shafts had reached depths on the incline of approximately 2,300 feet and 1,000 feet respectively. It has appeared in literature that the closing of the mines was due chiefly to the difficulty of handling the water. From information gathered from different men who knew the mines thoroughly when they were in operation, it would appear that such a statement is not correct. Below a depth of about 700 to 800 feet, where a reservoir was established from which the water was pumped to the surface, the Albert mine was remarkably dry.

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*"The Albert Mines and Capelton Chemical Works" by S. L. Spafford. —Journal of the General Mining Association of Quebec, Vol. II, 1894-95, pp. 214-220; also in Canadian Mining Review, Jan., 1895.

In the Albert mines, it was said that with increased depth, the ore-bodies became of smaller dimensions while in the bottom of the shaft the schist contained only disseminated grains and narrow intercalated bands of the sulphides. From information kindly furnished by Mr. S. L. Spafford, it would appear that down to a depth of about 2,000 feet in this mine, the hanging and foot walls were explored quite thoroughly in the hope of finding new ore-bodies. The ore-bodies removed from these mines were identical in their mode of occurrence and origin with those upon which work is now progressing in the adjacent Eustis mine at a depth of 3,750 feet. When one considers how variable have been the dimensions and number of the ore-bodies at different depths in the Eustis mine and realizes that at different times in its history dark days appeared when a search for ore was being made, then it seems reasonable to regret that the Albert shaft had not been extended for one or two hundred feet and at this increased depth further prospecting work done before the mines were abandoned.

The Victoria Mine.—Range VIII, Lot 4, N.E.¼.—"The Victoria Mine, on the fourth lot of the eighth range, appears to be a continuation of the deposit of the Capel mine on the same side of the trough. When first exposed at the surface, the deposit presented a breadth of twenty feet, holding yellow sulphurets of copper and iron, and a considerable quantity of rich ore was obtained from it, but the bed did not maintain the same productiveness on sinking to a depth of forty feet. An adit is now being driven across the measures to intersect the bed at a distance of about fifty feet from the surface." (Jas. Richardson in G.S.C., 1866, p. 42.)

"Yellow sulphuret and iron pyrites in chloritic slate. Great quantities of ore were obtained at the surface. This is the Victoria mine." (G.S.C., 1866, p. 307.)

In Ells' report of the G.S.C. for 1888-89, and also in the G.S.C. Bulletin on Copper, this property is mentioned as one of the "thirteen mines" that "were operated" in Ascot township prior to 1865.

"Yellow sulphurets and iron pyrites in chloritic slate—great quantities of ore obtained at surface. Six beds characterized by ore veins covering one-fourth of a mile—mine about to be reopened." (A Partial List of Copper and Sulphur Properties in the Eastern Townships, by J. R. Woodward, Sherbrooke, 1902.)

"It has been known for some time that pyrites occurs on the N.E.¼ of lot 4, range VIII, Ascot. This is the property immediately adjacent to the Capelton mines towards the east. Only a very small amount of surface prospecting has been done and the occurrence of ore-bodies of value is problematical. The strike of the ore-bearing zone in which the Eustis and Capelton ore bodies were found lies across this property, from which one would infer that careful prospecting would be warranted." ("Pyrites in Canada" by A. W. G. Wilson, Mines Branch, Ottawa, 1912, p. 59.)

This property is situated immediately to the northeast of the Capelton mines on Capelton hill. It comprises 57 acres on the northeastern quarter of lot 4, range VIII, held in fee simple, and the mining rights on 192 acres adjacent. Owing to the efforts of Mr. W. S. Dresser, of Sherbrooke, the title to the land is now legally clear.

The sericite schists, the metamorphic equivalents of quartz porphyry, that enclose the ore-bodies of the Capelton and the Eustis mines extend across this property. Prior to 1866, a shaft had been sunk to a depth of fifty-seven feet on a zone of the schist, quite heavily impregnated with pyrite and chalcopyrite, which is exposed for upwards of 100 feet with a maximum width of about twenty feet. The schists strike N.E. to S.W. and dip from 40° to 60° toward the southeast. Where the shaft is situated, a lenticular body of quite solid pyrite with small amounts of chalcopyrite possessed a width of about six feet. At a depth of about twenty-five feet, the shaft is said to have passed out of ore. About 300 feet to the southwest of the shaft, and fifty feet, more or less, down the slope, a tunnel was driven into the hill, cross-cutting the schists for a length of 270 feet. For about 220 feet the tunnel is straight and then for fifty feet bends more toward the north. The innermost portions of the schists traversed by the tunnel were found to be impregnated with pyrite and a little chalcopyrite. Here a winze was sunk to a depth of twelve feet on a stringer of quite solid sulphides that is said to have attained a width of about a foot. Assays of material taken across the mineralized zone at the surface have yielded from one to slightly more than two per cent of copper. In addition to the shaft and the tunnel, a few other small openings have been made on the property.

At the time of my visit (May 20, 1915), the shaft was full of water, and the entrance to the tunnel was completely blocked by collapse of the roof. The property is worthy of further prospecting. Three or four diamond drill holes at properly selected points would soon establish whether this property should continue to be considered as a possible source of ore, similar in character to that of the Eustis and Capelton mines.

Range VIII, Lot 7, Ascot.—Upon the "Mining Map of Ascot Township" published in 1908 by J. Obalski, then the Superintendent of the Department of Mines of Quebec, the presence of copper-bearing minerals is indicated upon this lot.

Locally, a few people refer to this property as "Colonel King's mine."* Three small openings, approximately nine, seven and three feet in depth respectively, have been made on the western half of this lot, where narrow bands of chlorite schist are impregnated with scattered grains and crystals of pyrite. From the deepest opening, some fragments of schist, of which the pyrite comprises about twenty-five per cent, may be taken, but such specimens are not representative. An examination of all of the rock exposures upon this lot did not reveal any location where it would seem advisable to renew prospecting operations.

The Ascot (or the Haskell Hill) Mine. Range VIII, Lot 8, W½, Ascot.—A specimen of "yellow sulphuret from a bed" on this property was exhibited at the London International Exhibition of 1862. In the Descriptive Catalogue of Economic Minerals of Canada (p. 16), issued by the Geological Survey of Canada upon that occasion, this mine is described as follows,—"The bed is five feet thick and occurs in a calcareous chloritic slate. The mine has been opened on a twist in the stratification, giving three courses of ore in the breadth of eighty feet, but the general plane of the bed dips about S. 65°. A pit has been sunk on the incline of the bed to a depth of five and a half fathoms from the surface, and the ore obtained from the excavation, without any dressing, has been sent to Boston, where it has yielded on an average about eight per cent of pure copper. The quantity of ore obtained from the bed by five men in five months is about 100 tons. The bed is traceable for a considerable distance in opposite directions from the pit, and carries copper as far as it has been tried. The horizon of the strata of this mine is supposed to be higher than the dolomite of Acton, and to be approximately equivalent to the chloritic slates of the Shipton and St-Armand synclinal."

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*This must not be confused with King's mine, lot 4, range XI, Ascot.

"On the eighth lot of the eighth range, at Haskell Hill is what is now known as the Ascot mine. The ore-bearing bed, which is about five feet in thickness, is an impure limestone, associated with chloritic schists. The dip of the strata at the mine is northward, at an angle of 72°, and a shaft has been sunk forty-three feet on the incline. From this a drift has been carried along the ore bed, about fifty feet to the west and thirty-five feet to the east. A transverse cutting was made from the bottom of the shaft twenty-five feet to the northward, the rock containing copper ore throughout, which may indicate a thickening of the bed. At the end of this distance, the copper-bearing bed had a southward dip at an angle of 75°, showing apparently an upward turn towards the surface, on the north side a of small synclinal fold. The bed has been traced for some distance on each side of the shaft. A little to the southeastward of this shaft another has been sunk for a few feet on a bed of ore, which dips southward at an angle of about forty-five degrees, and appears to be a repetition of the previous bed on the southern side of a small anticlinal. The ore of this locality consists of copper pyrites, which is disseminated in small strings and grains through a mixture of limestone and chlorite. Considerable quantities of the rock sent to market without dressing yielded eight per cent of copper." (Geology of Canada, 1863, p. 732.)

"The Ascot Mine was discovered about the year 1859 and was leased by the late Thos. McCaw, Esq. of Montreal. The copper-bearing bed in this mine differs very considerably from that at

Harvey Hill, both in its composition, extent, and regularity, the ore being the yellow sulphuret associated with a little iron pyrites; the matrix is composed of an impure limestone associated with chloritic schist; the average thickness of the bed varying between five and six feet."

"The limited means of the proprietor in this case for carrying on works, the very nature of which necessarily required a large amount of capital to open them up, with a view to the more profitable extraction of the ore, only enabled him to pay for the labour as he went on. In this he was tolerably successful, some of the ore yielding in the rough state as broken in the mine, and without any dressing as much as eight per cent of copper; whilst the poorer portion, from the nature of its matrix could, at small cost, be dressed to an average of twelve or fourteen per cent, with but small loss of its copper contents."

"The ore from this mine was discovered at the smelting works at Boston to contain within itself all the elements necessary for its reduction and liquefaction in the furnace, without requiring the aid of any foreign flux or admixture of other ores for the purpose of smelting it. In addition to which it was ascertained that this ore answered admirably as a flux for such ores as those from Acton and Harvey Hill mines, which are deficient in sulphur, and those from the Clark and other mines, containing silicious matters, requiring lime as a flux in their metallurgical treatment."

"The ore from this mine therefore may be regarded as of some importance, should smelting works be established on a large scale in the province, as may be inferred from the fact that this mine was, in the fall of 1863, purchased by an American Company who erected furnaces at Lennoxville for the smelting of the ores from this and other mines in the province; and operations were carried on by them for some time successfully and profitably; but the lamentable difficulties of our neighbors for the past two years, and the great difference between the value of their currency and ours, compelled, a few months ago (like many other enterprises in this province carried on with American capital), the temporary suspension, at least for the present, of their smelting as well as mining operations." ("Copper Mining in Canada East" by Herbert Williams. Quebec Lit. and Hist. Soc., 1865, pp. 47-48.)

"Yellow sulphuret disseminated in a breadth of five feet in calcareous chloritic slate. The deposit appears to be repeated twice by undulations, and in one of the bands a shaft has been sunk about 100 feet, from which, and the galleries connected with it, much ore has been obtained, part of which has been exported to the United States, a portion after having been concentrated by smelting near Lennoxville. This is the Ascot mine." (G.S.C., 1866, p. 307.)

"This mine situated on the eighth lot of the eighth concession in the township of Ascot has now become the property of the Sherbrooke Mining and Smelting Company, who are determined to resume operations on a more extensive scale. The shaft which is about 150 feet deep was being emptied of water when visited in 1882. The ore, yellow sulphuret, is derived from a two feet bed in chloritic mica schist. It is stated to average about seven per cent of metallic copper." (C. W. Willimott in G.S.C., 1882, p. 2g.)

"In 1859 the Ascot Mine was discovered by Thos. McCaw of Montreal, at Haskell Hill, and found upon examination to consist of a bed of copper pyrites mixed with iron pyrites, with a thickness of five to six feet, in a matrix composed of impure limestone and chloritic schist. This mine was, in the fall of 1863, purchased by an American Company, who erected furnaces for smelting the copper ore at Lennoxville." (R. W. Ells in G.S.C., 1888-89, p. 51k; also in G.S.C. Bulletin on Copper, 1904, p. 47.)

"The Ascot Mine, in the township of Ascot, which had been leased by its Canadian owners to Americans was worked to a small extent, chiefly of an exploratory nature, and a small shipment made, which was said to average about eleven per cent of copper. The property has been again taken possession of by its Canadian owners, who have also done some exploratory work at the old Acton mine, the results of which are reported as exceedingly satisfactory." (G.S.C., Vol. XII, 1889, p. 43s.)

"Mr. John McCaw reopened in July last, the old property known as the Ascot mine. This mine was worked from 1862 to 1865 by Thos. McCaw & Co., and the details of the work then done will be found in the Geology of Canada, 1863, p. 776; and in the report of 1866, p. 317, where it is stated that a large quantity of raw ore, containing eight per cent of copper was taken out and shipped to the

United States or smelted at Lennoxville. The works consisted of four shafts, the deepest of which was 125 feet, together with a certain length of drifts. These works are now filled with water. I visited this property in July last. The deposit is carried in a band of chloritic schist whose outcropping extends over a length of 1,800 feet with a pretty considerable width, judging from the position of the works. This band is accompanied, following the stratification, by lenticular veins of quartz strongly impregnated with chalcopyrite. At certain points these veins assume sufficient breadth to be worked independently. The direction of this mineral belt is N.E. with a dip of about 70°. Actually, the outcroppings of the mineral can be seen at the surface and in the neighbourhood of the old shafts. Further, at 100 feet, to the northwest of shaft No. 1 and at 70 feet to the east of the Harvey Shaft, an old winze was cleaned out to a depth of thirty feet, and a six feet exposure is being followed which transversely represents a four foot vein of good ore. By sinking thus eight feet, twenty to twenty-five tons of picked ore, probably carrying eight to nine per cent of copper were taken out, judging by a specimen which gave 17.82 per cent copper with a little silver. The surface croppings are important and seem to indicate that the ore-body covers a large surface, thus presaging a good future for the mine. It is situated at a height of 800 feet, above the level of the Massawipi river and at a distance of 4½ miles from Lennoxville station. Eight men were then occupied in prospecting at the mine." (J. Obalski, in Report of the Commissioner of Colonization and Mines, Quebec, 1896-97, p. 86.)

This mine was also worked on a small scale with half a dozen men by Mr. J. McCaw of Sherbrooke, who is now working it under the name of "the Syndicate of Five." According to a result communicated to us, a consignment of six tons, shipped to Swansea, gave fourteen per cent of copper, 1.75 oz. of silver and traces of gold. During the year 120 tons of ore were taken out and shipped. According to the latest information, the mine has been bonded to Messrs. H. Franklyn & Co., of New York with an option of purchase, and it is proposed to put in a compressor, capable of running four drills." (J. Obalski in Report of the Mines of Quebec for 1898, p. 12.)

In Mr. Obalski's report for 1901, work is said to have been resumed on the Ascot mine, by Wilfred Johnston of New York. "The ore is chalcopyrite, and the ore body has been opened by a shaft for 250 feet on a slope or to a vertical depth of about 170 feet. The ores are irregularly disseminated through quartz schist, in varying proportions, in a vein seven feet wide with a solid part in places of two feet in width." (G.S.C. Bulletin on Copper, 1904, p. 56.)

"The Ascot mine, in lot 8, range VIII of the township of Ascot, is another of the reopened properties. Under the direction of Mr. John McCaw, one of its owners, this mine is at present producing an excellent quality of ore." ("The Copper Deposits of the Eastern Townships of Quebec," by J. A. Dresser, G.S.C., No. 975, 1907, p. 6.)

"Owned by a Montreal syndicate. Manager—Mr. John McCaw. Operating lot 8, range VIII and owning the Johnson, lot 8, range IX, in Ascot township. Owned in fee simple. This mine was first opened in 1859, but was acquired by the present owners in 1899."

"The ore is slightly different in character from that found in the Eustis and Capelton deposits, not being so high in sulphur and iron contents. It carries from two to six per cent of copper with a small gold and silver content. Smelters samples on cobbed ore show varying percentages of sulphur, and from twelve to eighteen per cent of copper."

"Mining operations were carried on for eight months during the last year and a half. About 150 tons of ore were produced, and sold to the Nichols Chemical Company, which Company has so far bought all the ore produced. From three to five men are employed. Only one shaft is being operated. The plant is said to have cost $18,000, and includes: half of a duplex Rand compressor, of seven drill capacity, with a receiver; one Jenckes eighty horse power boiler; one hoist machine; drills, etc. The manager estimates that there are from 5,000 to 7,000 tons of ore on the dumps, which must be concentrated to recover values." ("Report on the Mining and Metallurgical Industries of Canada," Mines Branch, Department of Mines, Ottawa, 1907, p. 480.)

The Ascot mine was not in operation in 1909, when visited by A. W. G. Wilson who in his preliminary report on the copper mines of this district, states that: "The dumps at the Ascot mine contain a small quantity of rich ore." (Summ. Rept. of Mines Branch, Ottawa, 1909, p. 72.)

"The Ascot mine was unwatered by John McCaw of Sherbrooke and some sampling done for the East Canada Smelting Co., but no ore was shipped." (Mining Operations in Quebec, 1910, p. 56.)

A brief resumé of the history of this mine is as follows:—The Ascot mine was discovered about 1859 and was leased by Mr. Thomas McCaw of Montreal. In 1861, a shaft had been sunk to a depth of thirty-three feet from which about 100 tons of eight per cent copper were shipped to Boston. In the fall of 1863, the mine was purchased by an American syndicate. Small furnaces were erected at Lennoxville for the smelting of the ore from this as well as from other mines in the province. It was found that in smelting the ore from the Ascot mine, it was unnecessary to add "any foreign flux or admixture of other ores," and that "this ore answered admirably as a flux" for other ores. In 1864, both the smelter at Lennoxville and the Ascot mine were closed down. At that time the shaft had reached a depth of about 100 feet and considerable drifting had been done. This early work followed a vein that is said to have averaged between five and six feet in width.

In 1881 or 1882, the property was bought by Mr. John McCaw of Sherbrooke. The Sherbrooke Mining and Smelting Company was organized to operate the Ascot and other properties. In 1882, the shaft was being emptied of water, but there is no record available concerning the results of the operations of this Company. Apparently their work was of an exploratory character and may have extended over a period of from two to three years.

In July 1897, the mine was reopened and while extending an old winze in the Harvey shaft for a depth of eight feet, twenty to twenty-five tons of hand-picked ore, probably carrying eight to nine per cent in copper, were extracted. During 1898, the mine was worked for a Montreal syndicate under the name of the "Syndicate of Five;" 120 tons of ore were shipped, and a consignment of six tons sent to Swansea, in Wales, gave fourteen per cent in copper, 1.75

oz. of silver, and traces of gold. During the latter portion of 1898 the property was bonded to Messrs. H. Franklyn and Co., of New York with an option of purchase. In that year, it is reported that a small shipment of ore averaged thirteen per cent in copper. In 1899, it was again taken possession of by its Canadian owners, and a small shipment is said to have averaged about eleven per cent in copper. In September, 1900, Captain Francis Bennetts reported on the property to Messrs. Hanson of Montreal.

In 1901, the mine was leased to Wilfred Johnston of New York. The deepest shaft on the property had then reached a depth of 250 feet on a slope or a vertical depth of about 170 feet. In May, 1903, Captain Bennetts prepared a second report on the property. In this report, he describes the ore as occurring in the form of lenticular bodies, striking from N.E. to S.W. He mentions the presence of a fault, and concludes the report with the statement that:—"Notwithstanding the temporary derangement occasioned by the dislocation of the vein in the shaft, the sinking of the said shaft having fully proved the expectation that the ores extended in depth beyond 200 feet (the bottom of the mine in September 1900), and taking the favorable indication presented in the surface outcropping of the vein into consideration with the proved existence of the ores in depth, there are reasonable grounds for the expectation that further deposits of ore will be found laterally in this mine."

From 1905 to 1907, a small group of men were at work in the mine for a period of eight months. About 150 tons of ore are said to have been produced and sold to the Nichols Chemical Company at Capelton.

In 1910, the mine was pumped out, and some sampling was done for the East Canada Smelting Co. In 1913 the mine was again reopened but in September of that year, it again was permitted to fill with water.

All of the openings on this property penetrate chlorite schists' the metamorphic equivalents of either hypabyssal or volcanic rocks of the composition of a diabase or andesite. The strike of the schists varies from N. 60° E. to a few degrees north of west; the dip probably averages about 40° toward the south. In three of the open cuts, irregular dykes of a porphyrite, which show no evidences of having been subjected to pressure, traverse the schists

In hand specimens, the outline of former phenocrysts of plagioclase, up to a quarter of an inch in length, are sharply defined, but in thin section under the microscope it was found that the porphyrite has been almost completely altered to epidote, chlorite, zoisite, and leucoxene. These dykes appear to have been injected subsequent to the mineralization of the schists.

Work has progressed upon two very irregular shear zones that traverse the chlorite schists. Locally within these zones, the schists are irregularly impregnated with grains of pyrite and chalcopyrite, and occasionally have enclosed small "bunches" of ore. In addition, very irregular lenticular bodies of vein matter, composed of calcite, dolomite, quartz and chalcopyrite have been encountered at irregular intervals. In some instances, such bodies of ore are said to have locally attained a width of eight feet or more. In the course of the later working of the property, it does not seem probable that any body of ore has been found equal in dimensions to that removed by the early operators (from 1859 to 1864).

In addition to ten or more openings that may be designated either as open cuts or prospect shafts (one of which is forty feet, two are said to be twenty-five feet, and the others are less in depth), there are three deep shafts. The shaft that was worked in the early days is said to be about 100 feet in depth; considerable drifting was done and some quite large stopes developed in these old workings. Of the two shafts in the shaft house, that known as the Harvey shaft is said to be about 125 feet in depth on the incline; the other descends vertically and turning to an incline, reaches a depth of 340 feet. Surveyed plans of the mine, prepared in 1902, show that the underground workings are quite extensive; their disposition suggests that much of the work done was of an exploratory character.

In August, 1914, when the property was visited, a few tons of rich ore were stored in the shaft house, and small portions of some of the dumps might be concentrated with profit.

The deep shafts were full of water, but, judging from the mode of occurrence of its ore and from the history of the mine, it is plain that a very large measure of speculation must always be connected with any attempt to operate it.

The ore that has been extracted from this property has carried a higher average percentage of copper than any of the other properties in Ascot township. From information gathered, the writer is led to believe that if the mine were reopened, the first work would have to be directed in searching for ore.

The Wilson Mine—Range VIII, Lot 8, E½, Ascot.—"Yellow sulphuret in chloritic slate." (G.S.C. 1866, p. 307.)

A symbol indicating the presence of copper-bearing minerals at this point appears upon the geological map of the Eastern Townships (Sherbrooke Sheet), published in 1886 by the Geological Survey of Canada.

Under the above name this property appears on the Mining Map of Ascot Township by J. Obalski, issued by the Quebec Dept. of Mines in 1908.

Towards the western portion of the eastern half of this lot, two irregular openings were made in the early sixties, each of which attained a depth of about ten feet. Passing through glacial drift one of these openings penetrated the rock beneath to a depth of not more than one or two feet. In addition, some trenches were excavated to the bed rock which is chlorite schist. Widely separated bands of these schists, up to a few inches in width, contain scattered grains and small crystals of pyrite. A careful examination of both the exposed bed rock and of the loose material from the excavations failed to reveal the presence of any trace of copper.

Range VIII, Lot 9, Ascot.—The presence of copper upon this lot is indicated on the "Mining Map of Ascot Township," published in 1908, by J. Obalski, at that time the Superintendent of Mines of the Province of Quebec.

Approximately 250 and 200 yards, respectively, from the eastern and the northern boundaries of this lot, a small opening has been made by the discharge of one or two small blasts, in schistose quartz porphyry, striking N. 60° E, dipping approximately 45° to the southeast. The schists contain a few disseminated particles of iron pyrites.

Approximately 600 yards from the eastern boundary of this lot, and eighty yards from the line between lots 9 and 10 there is a depression about three feet in depth, marking the location of shaft which is reported to have been ten or twelve feet in depth. This opening penetrated chlorite-sericite schists, representing metamorphosed quartz porphyry, that strike N. 65° E. and dip about 60° to the southeast. Small quartz veinlets traverse the schists parallel to their schistosity. Small grains and crystals of pyrite are widely scattered within both the schists and these veinlets.

About 840 and 480 yards, recpectively, from the eastern and northern boundaries of this lot, a shaft has been sunk in similar schists traversed in a similar manner by quartz veinlets and containing widely scattered grains of pyrite. The shaft was full of water but the present owner of the lot once bailed the water out and found it to be "about twenty feet in depth." At the points where prospecting work has been done upon this lot, nothing of any value has been found.

The Dundin Mine—Range VIII, Lot 10, Ascot.—"Yellow sulphuret in chloritic slate." (G.S.C. 1866, p. 307.)

The presence of copper-bearing minerals on this lot is indicated on the "Mining Map of Ascot Township" published in 1908 by J. Obalski, then the Superintendent of Mines for Quebec.

In the "Partial List of Copper and Sulphur Properties in the Eastern Townships, P.Q., from which sufficient ore has been guaranteed to meet Capacity of Custom Smelter and Chemical Works proposed to be established at Sherbrooke, P.Q.," by J. Woodward of Sherbrooke, the Dundin Mine is mentioned among those mining properties within easy hauling distance of Sherbrooke.

None of the people living upon adjacent lots recognized this property, or any other, under the name of the Dundin Mine. Yet a family with this name owned this lot during the sixties when extensive prospecting operations were being carried on in a search for copper.

A few very small openings have been made, the largest of which is in chlorite schist and is less than two feet in depth. The schist contains a few small scattered grains of pyrite. It may be that a few particles of copper pyrites have been discovered within the schists upon this lot, but their presence was not observed by the writer.

The Lennoxville Mine—Range VIII, Lot II, Ascot.—"Yellow sulphuret in chloritic slates." (G.S.C. 1866, p. 307.)

It appears under this name on the Mining Map of the township of Ascot issued in 1908 by J. Obalski, at that time the Superintendent of Mines in the province of Quebec.

Here a pit about ten feet in depth has been sunk in chlorite schists that strike N. 53° E. and dip 50° to the southeast. The chlorite schists which are the metamorphosed equivalents of a diabase or closely allied rock, are traversed by a few veinlets of quartz and calcite within which small grains of chalcopyrite or pyrite occasionally may be found. The chlorite schist contains a few widely disseminated grains and small crystals of pyrite. The occurrence cannot be considered to be of any economic importance.

The Parks Mine—Range VIII, Lot 12, W½, Ascot.—"Yellow sulphuret in chloritic slate. Parks mine." (G.S.C. 1866, p. 307.)

This property is mentioned as one of "the thirteen mines" that "were operated" in Ascot township prior to 1865. (G.S.C. 1888-89, p. 50k; also in G.S.C. Bulletin on Copper, 1904, p. 46.)

Under this name it appears upon the "Mining Map of Ascot Township," published in 1908, by J. Obalski, then the Superintendent of the Department of Mines of Quebec.

Upon the northern portion of the western half of this lot, two shafts were sunk, the one about 200 yards and the other approximately 800 yards from the road crossing its northwestern corner. Mr. Giff who lives on the western part of lot 13, range VIII and who owns that portion of lot 12 upon which these shafts are situated, informed me that the one had a depth on the slope of about eighty feet while the other, farther from the road, reached a depth of slightly more than 100 feet; within the latter, one or two short drifts were driven.

The shaft approximately 200 yards from the road, penetrates quartz-porphyry which in part is much less schistose than in the vast majority of the numerous localities where this type of rock is exposed. In the Stoke Mountain belt, so common are the sericite schists, that have been derived from the metamorphism of this type of quartz porphyry, that a detailed description of the petrographical character of the rock from this locality has been given upon an earlier page of this report. In brief, it is a rock of light gray colour within which phenocrysts of quartz, plagioclase and orthoclase, up to one-fourth of an inch across, are scattered through a fine-grained groundmass of quartz and feldspar with a very few small grains and crystals of zircon; as secondary minerals, a little chlorite, sericite, calcite and some tiny crystals of rutile are also present. This shaft has been filled with rocks, but an examination of the loose rock fragments substantiates the statement of Mr. Giff that only pyrite was found at this point, and that not enough of this mineral was found to warrant a continuation of the work. Small grains and crystals of pyrite are disseminated through the rock, especially in its more schistose portions where they are distributed upon the planes of schistosity in such a manner that when the rock is broken across, they appear in linear arrangement as films or narrow veins of pyrite parallel to the foliation. One fragment upon the dump shows that at some point within the shaft, a vein, about one-half of which was pyrite and the remainder of quartz, sericite, etc., attained a width of at least fourteen inches.

The deeper shaft which is further removed from the road is now surrounded by a very thick growth of spruce and balsam. It is situated at the contact between the light coloured sericite schists and dark chlorite schists, the former being the footwall and the upper the hanging wall. Some of the schistose quartz porphyry here contains more chlorite than usual for this district. Both the chlorite and sericite schists here contain disseminated grains of a yellowish to brownish ferrodolomite, the glistening cleavage surfaces of which are often half an inch across; similar schists impregnated by the same carbonate occur at many localities in the district. Grains and crystals of pyrite, up to half an inch across, together with some grains of chalcopyrite are distributed irregularly upon the planes of schistosity within some bands of the schist. Narrow veins of these sulphides with quartz and ferrodolomite alternate with bands or leaves of the schists. In so far as could be determined from a study of fragments on the dump, the maximum width attained by one of these veins was nine inches, about one half of it being composed of pyrite with a little chalcopyrite. A very small pile of ore lies to the east of the large dump of country rock taken from the shaft. Some good specimens of copper ore may be selected from this pile which is so pitifully small in contrast to the great quantity of waste rock. The story was repeated to me by different persons that the vein was only a few inches in width but contained good copper ore; that in sinking the shaft the vein was lost because the work was done by contract and the rock above the vein was easier to work than that which would have been encountered by following the vein. The shaft is full of water and in its vicinity exposures are too limited to come to a clear understanding of the relations. Certain it is that operations were suspended because those interested did not find enough ore; equally certain is it that this property should not be considered to be of value as a definite source of copper ore.

Rang VIII, Lot 13, Ascot.—On northern half of lot—"Yellow sulphuret in magnesian limestone;" on southern half "yellow sulphuret in chloritic slate." (G.S.C. 1866, p. 307.)

The presence of copper upon this lot is indicated on the "Mining Map of Ascot Township" published in 1908 by J. Obalski, then the Superintendent of Mines of Quebec.

Approximately 900 yards and 250 yards, respectively, from the eastern and the northern boundaries of this lot, a trench, twenty feet in length with a maximum depth of about ten feet, has been excavated transverse to the strike of chlorite-sericite-schists. Parallel to their schistosity, these schists are traversed by a few narrow quartz veins. Within some narrow bands of the schists as well as in the quartz veins a few grains and crystals of pyrite are present.

At a point within the southeastern quarter of this lot, a shaft was sunk to a depth of a few feet in chlorite schists containing scattered grains of pyrite. The shaft has been filled up with empty tin cans and other rubbish.

The Short Mine—Range VIII, Lot 14, Ascot.—"Yellow sulphuret in chloritic slate. Several extensive openings have been made with a fair show of ore." (G.S.C., 1866, p. 307.)

This property is mentioned as one of "thirteen mines" that "were operated" in Ascot township prior to 1865. (R. W. Ells in G.S.C. Vol. IV, 1888-89, p. 50k; also in G.S.C. Bulletin on Copper, 1904, p. 46.)

Under this name it appears upon the Mining Map of Ascot Township, published in 1908 by J. Obalski, at that time the Superintendent of Mines for Quebec.

A shaft, approximately forty-five feet in depth, was sunk upon a narrow irregular rusty band of sericite schists, the metamorphic equivalent of quartz porphyry of a type similar to that which occurs at the Parks mine, the Suffield mine, etc. This shaft is situated at a point about midway between the road and the western boundary of lot 14, and about fifteen yards from the line between lots 13 and 14, range VIII. At variance to the general northeasterly strike of the region, here the schists strike N. 20° W, dipping 50° to the northeast. Small grains of pyrite together with a very few particles of copper pyrites are scattered through the narrow irregular band where the schists appear rusty upon exposed surfaces.

Seven or eight years ago, the Grey Nuns (the Sisters of Charity) who now own this property, had this shaft cleaned out, and it is now the source of their water supply. Mr. Giff who lives upon the adjoining property (lot 13, range VIII) and who, in the early sixties, worked in this shaft, informed me that where the shaft is situated a portion of the rusty band of schists, up to a few inches in width, was so impregnated with pyrite and a little copper pyrites that these minerals composed about one-fourth of the whole. With depth this small vein soon died out with exception of scattered particles within the schist. One of the men who assisted in cleaning out the shaft stated that he was puzzled to know what the early operators were looking for. Very little ore was found and no shipment was made. Nothing suggests that the present useful mission of the shaft should be disturbed by renewing prospecting operations.

The Eustis (or the Crown) Mine.—Range IX, Lots 2 and 3, Ascot.—When worked on lot 4, it was known as The Lower Canada or The Hartford Mine. This mine has been operated continuously since 1879; from its discovery in 1865 to 1879, 80,000 to 90,000 tons of ore were extracted. It seems certain that more than a million tons of ore have been shipped from the property. At present work is progressing at a depth of 3,850 feet on an inclined slope that averages about 38° to the southeast.

In the literature pertaining to copper mining in the Eastern Townships, references to this mine are so numerous that they will not be repeated in this report. Anyone desirous of reading the most important of such references, should consult:—(I) Geological Survey Report for 1866, pp. 40-41; (II) Catalogue of the Economic Minerals of Canada, Philadelphia International Exhibition, 1876, p. 28; (III) Geological Survey Report for 1887, p. 845; (IV) A paper by Mr. John Blue—in the Canadian Mining and Mechanical Review, June 1893, pp. 110-112; (V) G.S.C. Report on the Copper Deposits of the Eastern Townships by J. A. Dresser, 1907, pp. 10-11; (VI) A paper by Mr. J. M. Passow in the Canadian Mining Journal, July 1, 1912, pp. 463-464.

Sericite schists, the metamorphic equivalents of quartz porphyry, strike N.E. to S.W., and dip toward the southeast. These schists enclose lenticular bodies of ore that are arranged en échelon; some of the lenses overlap, and sometimes parallel bodies of ore are separated by only a few feet of schist. None of the individual ore lenses have exceeded 350 feet, and the majority of them have been from 100 to 125 feet in maximum length on the strike. Some have attained a thickness of sixty feet or more. With depth the ore-bodies narrow and swell and sometimes have practically pinched out; according to Dr. A. W. G. Wilson of the Mines Branch, Ottawa, who spent several weeks in making a detailed study of the old workings, the largest ore-lens encountered possessed a length of 800 feet on the dip. As is pointed out by Dresser:—"The miners have learned when a lens is exhausted to drift to the right to find the next. That is in proceeding along the strike toward the northeast, each succeeding lens appears on the southeast side of the previous one, i.e., in the hanging wall, and in going toward the southwest, the next ore-body is to be looked for on the northwest or in the foot wall."

With depth, the dip of the schists varies from 25° to 70°, the average being about 38°. In sympathy with the "rolls" or "waves" in the schist, the dip of the ore is either comparatively steep or gentle. The walls of the ore-bodies are not sharply defined. Solid ore passes gradually into sericite schists containing less and less of the sulphides. Usually the thickness of schist carrying disseminated sulphides is greater on the hanging wall than on the footwall. Occasionally curtains of schist descend into the ore and sometimes "horses" of schist are encountered. The marginal portions of such curtains and "horses" are heavily impregnated with ore. In at

Pl. VIII

The Eustis mine, Range IX, lots 2 and 3, Ascot township.

least one instance, one of these curtains was regarded, for a considerable time, as a sound footwall, but a pleasant surprise followed when it was discovered that a considerable thickness of good ore lay beneath it.

The ore is granular pyrite, carrying a little chalcopyrite, a small amount of zinc blende and galena, occasionally a very little pyrrhotite and low values in silver and gold. In some of the ore a little tetrahedrite has been observed; in the report of the Geological Survey for 1877-78, p. 52g, an assay of a specimen of ore containing a steel grey tetrahedrite is reported as having yielded 75.03 ounces of silver to the ton. The copper content of the ore has been variable. The records of the early mining show that at first the ore was very much richer in copper than it is at present; probably this was the result of downward sulphide enrichment. In any individual ore-lens, copper values in general are somewhat higher toward the walls, and especially toward the footwall. Not only does the chalcopyrite occur in the form of widely disseminated grains but also as irregular streaks within the pyrite. The average copper content of one lens of ore is not a true index of what that of the next will be. In 1913, the ore carried slightly less than two per cent in copper; at present, it averages about two per cent. Approximately one ounce of silver, per ton, is present for each per cent of copper. The gold values are very low; in 1893, Mr. John Blue stated that they amounted to about forty cents per ton of 2,000 lbs. A large proportion of the ore contains from forty to forty-five per cent of sulphur.

Intimately associated with the ore are irregular streaks or bands of what is called "green rock" by the miners. Locally present both on the hanging and foot walls, "horses" of this type of rock also have been encountered within the ore. In hand specimens, it is a massive fine-grained greenish-gray rock which is somewhat darker in colour than the sericite schists. Usually the "green-rock" contains scattered grains of pyrite. When examined under the microscope it is found to consist chiefly of grains of dolomite with considerable quartz and sericite and numerous minute prismatic crystals of rutile. Study both in the field and under the microscope has led to the conclusion that this "rock" has resulted from the alteration and partial replacement of the schistose quartz porphyry by carbonate-bearing waters.

Both the "green-rock" and the bodies of sulphides have been produced by replacement of the sericite schists along shear zones where the schistosity has been well developed and where, because of a strong tendency to overthrusting, the schists were cast into "rolls" or "waves." Occasionally, the banding and the crenulations that characterized the schists prior to their replacement may be observed both in the ore and in the "greenrock." It would seem that the mineralization must have taken place through the agency of ascending waters, either after or toward the closing stages of the period during which the quartz-porphyry was converted into sericite schists. That the ore-bodies also have been subjected to later pressure is shown by the manner in which some of the pyrite is traversed by minute fractures.

Subsequently, the district has been intersected by faults striking north of west with downthrows toward the north. Usually the throw of such faults has not exceeded a few feet. A few hundred feet below the tunnel, a fault was encountered which cast the ore-body about twenty-five feet into the hanging wall; here a long drift, known as the "slide-drift" was then extended for over 900 feet toward the southwest. At the nineteenth level below the tunnel (about 2,450 feet below the collar of the Hartford shaft), there is a fault which has a throw of about sixty feet. It is said that the search for ore beyond this fault proved to be so discouraging that the mine was about to be closed down when a final effort fortunately discovered the continuation of the ore-body in the hanging wall.

Dark dikes, which display no evidence of having been subjected to pressure, traverse the schists and ore-bodies. They include camptonites and monchiquites and other types of rock similar to those from dikes in the vicinity of Mount Royal, Montreal, and other of the Monteregian hills. In the shaft, between the thirtieth and thirty-first levels, a large coarse-grained dike contains phenocrysts of olivine and augite, some of which are an inch across. In thin section, this rock closely resembles the olivine-rich variety of essexite from Mount Royal to which Dr. F. D. Adams has given the name of Montrealite. The majority of these dikes trend N.E. to S.W. Whether they are cut by the faults described in the last paragraph was not determined. Immediately adjacent to the dikes, where they intersect the ore, the percentage of copper increases. Apparently the waters, attending the injection of these dikes have gathered some of the chalcopyrite in the ore and redeposited it in the vicinity of their contacts.

When discovered in 1865, this property was called the Lower Canada mine. In that year, 400 to 500 tons of twelve per cent copper ore was produced. In the following year, under the name of the Hartford mine, it was worked by General Adams of the United States, who, in five years, extracted "not less than 25,000 tons of ore." Under his management, a furnace was erected about a mile and a half from the mine and up to June, 1869, about 20,000 tons of ore had been smelted to forty per cent regulus on the spot. This regulus was then sent to Bergenport, New Jersey, for treatment. Desirous of saving the sulphur in the ore, General Adams also erected a small sulphuric acid works near St. Johns, Quebec; but there was no market for the acid and the project was abandoned.

In 1872, the property passed into the possession of the Canadian Copper and Sulphur Company of Glasgow, Scotland. It is known that up to November, 1877, this company removed from 55,000 to 65,000 tons of ore from the mine. In 1876, it yielded 22,388 tons of ore. Reduction works comprising about eighty burners and sixty furnaces were erected at Capelton to treat the ore by Henderson's wet process. It is stated that in 1876, from sixty-five to seventy tons of precipitate, containing seventy to seventy-five per cent of copper were produced monthly. From the first of January to the 27th of October, 1877, 13,170 tons (each of 2,240 lbs) were mined and treated on the spot; a hundred tons of ore, containing eleven and a half per cent of copper, were shipped to England, and 1,388 tons of sulphur ore sent to London, Ontario.

It is stated on good authority that the operations of this company were not a financial success. Apparently during at least the major part of 1878 and for a portion of 1879, the mine was closed. In 1879, the Orford Nickel and Copper Co., later known as the Orford Copper and Sulphur Co., with Major R. G. Leckie as superintendent, leased and reopened the Hartford shaft. It is reported that this shaft which is situated on lot 4, range IX, about 200 feet north of the boundary with the property of the Orford Nickel and Copper Co. (lots 2 and 3, range IX), had reached the line at a depth of about 500 feet on the slope.

At first this company had a lease from the Glasgow company both of the Hartford shaft and of the old smelting works at Capelton. Subsequently, in order to confine their operations to their own lands, a tunnel, 1000 feet in length, was driven into the hill, 550 feet below its summit, so that it meets the old Hartford shaft at a depth of 550 feet. For a time, they roasted some of the ore at the Scotch company's old works, the resulting cinder being smelted in a blast furnace, and some of the copper then refined into ingot.

Shortly after 1880 a new smelting plant, including fifty roasting ovens, with a capacity of 1,000 tons a month and two furnaces; was built at Eustis where the concentrating mill now stands. This plant was operated for a few years; but the escaping fumes so damaged the vegetation that the company were soon in trouble with the farmers of the community. It is also claimed that the price of copper declined (19.12 to 10.83 cents per lb.) so rapidly that from 1882 to 1885 the smelting operations were unsuccessful from a financial point of view.

The published data concerning the production of this mine during the earlier days of its operation while under the name of the Crown or Eustis mine, are restricted to the following brief statements. In 1885, the Eustis mine produced 16,000 tons. In 1888, 27,348 tons of ore were shipped, and 1,500 tons were burnt in piles, the total production for the year thus amounting to 28,848 tons. In 1889, the output was 34,089 tons, including 1,773 tons of matte.

In 1885, the mine had reached a depth of 1,150 feet; in 1886, a depth of 1,325 feet; in 1887, it was 1,600 feet deep.

For the year ending June 30th, 1890, it produced 28,955 gross tons of first grade ore and 3,327 tons of fine or second-grade ore; of this amount, 10,625 gross tons were smelted, and 18,328 tons were shipped to points in the United States. Apparently this was the last year in which smelting operations were carried on at the Eustis mine. In 1893, the mine had reached a depth of over 2,000 feet. Writing in June of that year, Mr. John Blue, then the managing superintendent, stated that "the output of the mine at the present time is at the rate of 3,000 tons of dressed ore per month, and has averaged this quantity for the past year or two." He then estimated that:—"Since it was first opened the mine has produced somewhere about half a million tons of ore, and judging from the general appearances of the vein in the bottom, it will in all likelihood produce as much more, and possibly then be a long way from being worked out." The decline in the price of copper in 1894 (when the average price was 9.5 cents a pound) caused both the Eustis and the Capelton mines to reduce their staffs by more than one-half.

In 1903, the Eustis company installed an electric plant, the power being supplied by falls on the Coaticook river, about two miles from the mine. In 1904, the construction of the crushing and concentrating plant close to the Boston and Maine railway was completed. From 1905 to 1907 inclusive the quantity of ore shipped must have been approximately 87,000 tons. In 1908, 26,598 tons were shipped and in 1909, 35,100 tons.

In 1912, a depth of 3,450 feet on the incline had been reached. At that time work was progressing upon "four well-defined lenses," the dimensions of which were approximately as follows:—"Footwall vein, 50-100 feet long by 4 to 20 feet thick; main vein 100-120 feet long by 20 to 60 feet thick; shaft vein 50-100 feet long by 3 to 15 feet thick; and No. 1 vein 20-120 feet long by 2 to 25 feet thick. The footwall vein and shaft vein are richest in copper, averaging from 4 to 8 per cent, while the main and No. 1 vein are richest in sulphur, running 42 to 48 per cent S., and 2½ to 4 per cent Cu."*

From 1910 to 1914 inclusive, about 153,849 tons of ore were shipped from the property. For the six years ending May 31st 1914, 223,961 tons were hoisted from the mine; much of the ore was concentrated and a relatively small quantity placed in stock piles; hence the figures representing shipments are lower than those pertaining to the tonnage hoisted. It is said that the ore shipped in 1913 carried on the average slightly less than two per cent of copper.

At present, work is progressing at a depth of 3,850 feet on the incline. Only two lenses of ore are present, the largest of which, possessing a maximum exposed thickness of about fifteen feet lies in the footwall, while the other is in the hanging wall. The ore now carries an average content of about two per cent. At depths of only a few hundred feet below the tunnel, and also at the twentieth level (about 2,500 feet below the collar of the old Hartford shaft) portions of bodies of ore that were left behind in the course of the earlier working now are being removed.

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*The Eustis mine, by J. M. Passow, Canadian Mining Journal, July 1st, 1912.

The maximum capacity of the mine equipment is about 200 tons per shift. The concentrating mill has a capacity of about twelve tons of mill feed per hour. In 1913, an Elmore oil concentrator was installed. In April, 1915, the Company's electric power plant burned down, but since, for some years, they have purchased some power from the Sherbrooke Railway and Power Co., they fortunately were able to make immediate arrangements whereby delay was avoided.

The Calhoun Mine—Range IX, Lot 5, Ascot.—This property is mentioned in the "Partial List of Copper and Sulphur Properties in the Eastern Townships, P.Q.," by J. B. Woodward of Sherbrooke, published in 1902. The statement is made that "This mine is now being worked."

Prospecting work has been performed at two points upon this lot. Situated about 800 yards from the road between ranges VIII, and IX, and about 220 yards from the line between lots 5 and 6 of range IX, near the foot of the northern slope of a low hill, a shaft has been sunk to a depth of twenty feet. The shaft was dry at the time it was examined by the writer; it penetrates a lenticular vein of dark grains of granular quartz enclosed within chlorite schists. The quartz vein strikes north 72° east and dips 65° toward the southeast. Its length could not be determined, but in the shaft the vein possesses a maximum width of seven feet. Upon exposed surfaces, the vein is very rusty due to the oxidation of pyrite which occurs in the form of small disseminated grains and crystals and occasionally as small veinlets. Upon careful search a few particles of copper pyrites may be found. The chlorite schists, immediately adjacent to the vein, contain a few small scattered grains of pyrite. The bluish granular quartz is traversed by later irregular veinlets of milky quartz containing a few small flakes of specular hematite.

Upon this same lot, about 500 yards from the road between ranges VIII and IX, and approximately 120 yards from the line between lots 5 and 6 of range IX, a small opening has been made as a result of the discharge of one or two small blasts of dynamite. Here, a narrow band of chlorite schists is impregnated with pyrite. A very few hand specimens may here be collected within which the pyrite would comprise about one-fourth of the whole. In tracing the pyritiferous band along the strike it is very irregular, the pyrite content disappearing within a few feet.

In the vicinity of neither of the above localities do indications suggest the advisability of renewing the prospecting operations.

The Marrington Mine—Range IX, Lot 6, N.E.$\frac{1}{4}$, Ascot.—Immediately following a brief description of the Belvidere mine in the Geology of Canada, 1863, the statement appears that—"A great bed of the same ores (iron and copper pyrites) is found on the sixth lot of the ninth range."

"Yellow sulphuret with much iron pyrites in a bed of between two and three feet in chloritic slate. A shaft has been sunk about 240 feet, and galleries driven nearly 300 feet. This is the Marrington mine." (G.S.C., 1866, p. 307.)

"A shaft has been sunk on a bed of from two to three feet thick, which at the surface displayed a nearly solid mass of compact iron pyrites, with very little copper, enclosed in micaceous slate; but this shaft has now been carried down about 240 feet, and for the last fifty feet the bed has so much improved as to yield about eight hundredweight of eight per cent copper ore to the fathom." (Jas. Richardson in G.S.C., 1866, p. 42.)

This property is mentioned as one of "thirteen mines" that "were operated" in Ascot Township prior to 1865. (R. W. Ells in G.S.C., Vol. IV, 1888-89, p. 50k; also in G.S.C. Bulletin on Copper, 1904, p. 46.)

In the same reports on pages 51k and 47, respectively, it states that:—"What was afterwards the Marrington mine on lot six of the ninth range, showed a vein of from two to three feet at the surface with a large proportion of iron pyrites."

The Marrington mine was worked during the early sixties (probably from 1861 to 1866) by an English Company. From the nature of the work that was done, it seems probable that little, if any, ore was shipped during that period. It is known that the company. suffered heavy financial losses.

In 1910 and 1911, Mr. A. O. Norton reopened the main shaft. A small twenty horse power boiler and a hoisting engine were then installed. The drilling was done by hand. According to Mr. W. Jenkins, who superintended the operations for Mr. Norton, the shaft was found to have a depth of 240 feet on an incline of about 40° toward the southeast. Several hundred feet of drifting had been done in the early days. The longest drifts are those at depths on the incline of 114 feet and 202 feet that extend for about 310 feet and forty feet, respectively toward the southwest. Shorter drifts extend to the northeast, and some crosscuts, one of which is ninety feet in length, connect with other drifts in "the footwall." Mr. Jenkins informs me that he directed the work along an irregular band of schist in the footwall, which is impregnated with pyrite, and within which there is a narrow streak containing a little chalcopyrite; that, from this streak, five tons of ore were shipped that carried three per cent in copper.

This shaft is situated upon the eastern slope of a low hill, near the northern boundary of the lot. Here chlorite schists, striking northeast and dipping 40° to 45° toward the southeast are irregularly, though in part heavily, impregnated with grains and small crystals of iron pyrites. About forty-five yards northwest of the shaft these schists are much contorted and, because of the presence of very irregularly distributed grains of pyrite, are rusty for a width of outcrop of about sixty feet. An opening, the depth of which was not ascertained, has been made at this point. Nor was the exact depth learned of a shaft in chlorite schists carrying a little pyrite that is situated about eighty yards southwest of the main shaft; judging from the dump it would appear to be somewhat more than fifty feet in depth.

From surface indications, and from what otherwise can be learned concerning this property it is plain that, although irregular streaks of the pyritiferous schists do carry a few scattered particles of chalcopyrite, at present it cannot be considered as a source from which copper ore can be economically produced. In the material upon the dumps, only occasional traces of the presence of copper can be found. Moreover, the pyrite appears to be so irregularly distributed in the schist, that if the vein below is of this character, under present standards it would not be profitable to consider processes of concentration to recover the sulphur values.

The Hepburn Mine—Range III, Lot 7, E½, A scot.—"Yellow sulphuret in chloritic slate." (G.S.C., 1866, p. 307.)

"This mine, situated about 3,000 feet to the S.W. of the Ascot mine, is also the property of the Sherbrooke Mining and Smelting Company. A shaft has been sunk to the depth of 156 feet. At sixty feet, a level has been driven thirty feet; from this a north and south cross-cut was made; the latter was carried 110 feet, at which distance a bed of yellow sulphide, twenty-four feet thick was cut, averaging about seven per cent of metallic copper. The north cross-cut was carried 125 feet where another bed of yellow ore was cut, said to be twenty-seven feet thick. No ore has been raised, the object of the company being to develop a large reserve. About twenty men are employed at this mine." (C. W. Willimott in G.S.C., 1880-81, p. 2g.g.)

The above information is repeated by R. W. Ells in G.S.C., Vol. IV, 1888-89, p. 55k; also in G.S.C. Bulletin on Copper, 1904, p. 51.

In the same reports, on pages 50k and 46 respectively, Ells mentions the Hepburn mine as one of several mines opened up since 1866 "which promise well in view of the great present demand for sulphur ores."

"Since the month of July (1896) the Eustis Company has re-opened the abandoned Hepburn mine on lot 7, range IX, Ascot. Five or six men are prospecting and are at present engaged in sinking under contract, an inclined shaft on a vein which presents croppings of some feet at the surface. That shaft is now sixty feet deep, and the ore taken out seems richer in copper than the average of that region. Preparations are also being made to resume work on an old shaft which has about the same depth." (J. Obalski in Report of the Commissioner of Colonization, Quebec 1895-96.)

"The Eustis Mining Co., also worked the Hepburn mine. On the occasion of my visit, there were eight men at work. Three shafts of 200, 60 and 45 feet have been sunk in a pretty rich ore deposit, sometimes carrying six to fourteen per cent of copper.

Actually, the forty-five foot shaft which shows a vein of four feet is being worked on a length of thirty feet." (J. Obalski, in the Report of the Commissioner of Colonization, Quebec, 1896-97.)

"The Eustis Mining Co., also did some work in the old Hepburn mine which it had already worked some years ago, and whence a little good ore has been got out, the working having shown that a good deposit exists there." (Mining Operations in the Province of Quebec by J. Obalski, 1904, p. 30.)

"The Eustis Mining Company has installed a small hoist at the old Hepburn mine, and is engaged in reopening the mine. At the present time an ore band about four feet in width, carrying pyrite and chalcopyrite has been exposed in the bottom of the old shaft." (A. W. G. Wilson, in Summary Report of Mines Branch, Ottawa, 1909, p. 71.)

The openings in this property are situated a few hundred yards from the eastern boundary of the lot. Capelton station on the Boston and Maine railway is about two and a half miles distant.

Sericite and chlorite schists, striking N. 55° to 60° E., dip at angles of 40° to 60° toward the southeast. Where the major portion of the work has been performed the sericite schists are quite heavily impregnated with pyrite and a little chalcopyrite. The sericite schists are the metamorphosed equivalents of quartz porphyry; in their light grayish to grayish-green colour and in their composition they are identical with the schists of the Eustis, Capelton, Suffield, Howard, and some other mines of the district.

The first prospecting work was done on this property in 1880 or 1881. At (1) in the accompanying sketch an inclined shaft was sunk which according to Willimott, in 1882, had reached a depth of 156 feet and from which at a depth of sixty feet, cross-cuts were extended toward the northwest and the southeast for 125 feet and 110 feet respectively. Work was suspended in 1883.

From 1895 to 1897, the Eustis Mining Company carried on some prospecting operations. Apparently it was at this time that the shaft, designated as (3) in the sketch, was sunk to a depth which is reputed to be sixty feet with a drift at the bottom toward the southwest. This company, which now owns the property, also carried on mining work upon it in 1904 and again in 1909 and 1910.

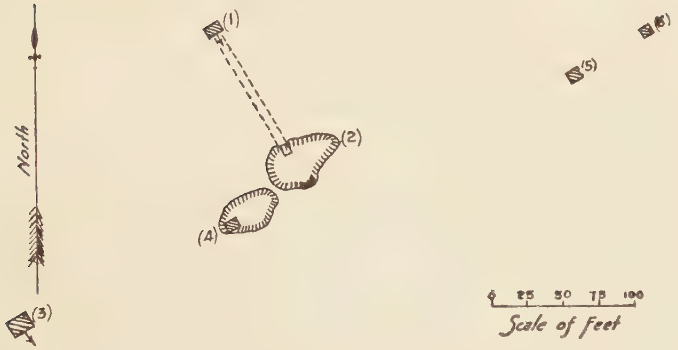

Fig. 8.—Surface plan showing the approximate relative positions of the workings at the Hepburn mine.

From the open pits (2) and (4) in sketch, two irregularly lenticular or kidney-like bodies of ore were removed, some of which carried from seven to eight per cent of copper. The ore taken from the open pit (2) had previously been encountered in the cross-cut extended from shaft (1). In the southwestern corner of open pit (4) an inclined shaft was sunk; in 1910, this shaft was extended to a depth of about 200 feet, and at the bottom the mineralized zone was followed by drifting for about forty feet. The ore-bodies removed from the open pits were local expansions of the mineralized zone of schist which in the shaft is said to have possessed an average width of about two feet and to have carried very low values in copper. Mr. L. N. Adsit, managing superintendent for the Eustis Mining Company at the time this shaft was put down, informed me that before closing down, the ore in sight that could be profitably removed had been extracted. Although its location was not observed by the writer a diamond-drill hole was put down to the southeast of open cuts (2) and (4).

At (5) and (6) in the sketch, prospect shafts are situated; the former probably having a depth of fifteen feet in chlorite schists impregnated with pyrite and occasionally a few particles of chalcopyrite, and the latter of 6 feet through glacial drift to the bed-rock.

Fifty yards, more or less, northwest of shaft (1), a few very small openings and outcrops show the presence of a band of chlorite schists irregularly impregnated with grains and small crystals of pyrite.

Farther westward on the lot and closer to its northern boundary, a small vein, with a maximum width of twelve inches and a length exposed of about twelve feet has recently been discovered. Towards its southwestern end, where it has a width of four inches, this vein cuts transverse to the schistosity. For a width of three or four feet, the chlorite schists adjacent to this vein contain widely scattered particles of pyrite and a few of chalcopyrite. In May, 1915, two men were engaged in opening up this exposure.

The ore removed from this property by the Eustis Mining Company is said to have slightly more than reimbursed them for their expenditure. It is to be hoped that further prospecting may reveal the presence of other bodies of ore similar to those taken from the open cuts. It would seem advisable to trench, at intervals, across the extension of this mineralized zone, especially between open cut (4) and shaft (3).

The Newell Hill (or the Hill) Mine.—Range IX, Lot 8, E½, Ascot.—"Yellow sulphuret in chloritic slate. The Hill mine." (G.S.C., 1866, p. 308.)

Both in the G.S.C. report for 1888-89, p. 50k and in the G.S.C. Bulletin on Copper, 1904, p. 46, Ells mentions this property as one of the "thirteen mines" that "were operated" in Ascot township prior to 1865.

To-day, practically the whole of this lot is covered with a healthy second growth of bush. In the early sixties, on that portion of the lot here referred to, three shafts were sunk in sericite schists carrying a little disseminated iron pyrites and possibly a few widely scattered particles of copper pyrites. Although the depths of these openings was not ascertained, it does not seem probable that the deepest of them exceeds twenty-five or thirty feet. The opening to which visitors are directed is really a small open cut in the side of the hill, a short distance from the southern boundary of the lot; a narrow and very irregular stringer, with a maximum width of two inches, with a little copper pyrites is exposed that trends parallel to the schistosity. At none of the points where work has been carried on, do the indications suggest the advisability of renewing operations.

On the summit of the hill, near the western end of this lot, quite extensive prospecting operations were carried on under the name of the Belvidere (or Clark's) iron mine. In places along a zone a few feet in width, chlorite schists have been partially replaced by magnetite. Very misleading reports are in existence concerning this property. Specimens have yielded as high as 57.15 per cent of iron, but such specimens are very exceptional. Some narrow bands, a few inches in width that in places are quite rich in magnetite are irregularly distributed through chlorite schists that contain relatively small percentages of iron or are barren. Two or three shafts, one of which must be quite deep, and several smaller openings have been made along the strike of this band. The material removed from these openings was of much too low a grade to place on the market as an iron ore. Some fragments on the dumps show that locally the chlorite schists were quite highly impregnated with pyrite.

The Belvedere Copper Mine.—Range IX, Lot 10, Ascot.—"On the ninth range of Ascot and on the tenth lot, near the line of the eleventh, there is a considerable breadth of fine white micaceous or nacreous slates, with which is interstratified a bed of greenish and greyish quartzose mica schists. This is in part chloritic or talcose, and contains large quantities of a mixture of iron pyrites with yellow copper ore, the latter being irregularly distributed. A few tons of the rock having been removed by blasting, selected portions of this gave, when dressed, one-half their weight of ore, which contained one-third of siliceous matters and 7.3 per cent of copper, the remainder being iron and sulphur. The breadth of this bed, which has an eastward dip of about 30°, is not far from six feet, and it is estimated that it will yield two tons of dressed ore similar to the above, to the fathom." (G.S.C. 1863, p. 732.)

"Yellow sulphurets in micaceous and chloritic slate disseminated with iron pyrites in a breadth of three feet. This is the Belvedere mine." (G.S.C. 1866, p. 308.)

This property is mentioned as one of thirteen mines that "were operated" in Ascot township prior to 1865. (R. W. Ells in G.S.C. Vol. IV, 1888-89, p. 50k; also in G.S.C. Bulletin on Copper 1904, p. 46.) In the same reports Ells states that the Belvedere mine is referred to in the Geology of Canada, 1863, and that "the breadth of the ore in the Belvedere lode was estimated at six feet." (G.S.C. Vol. IV, 1888-89, p. 51k; also in G.S.C. Bulletin on Copper, p. 47.)

Under this name it appears on the "Mining map of the Township of Ascot," published in 1908 by J. Obalski, then the Superintendent of Mines for Quebec.

This "mine" is situated about 700 yards from the eastern boundary of this lot, and twenty yards south of the road following the line between the lots 10 and 11. The shaft follows the dip of sericite-chlorite schists, the metamorphosed equivalents of quartz-porphyry that strike N. 60° E. and is approximately 45° to the southeast; on the slope it is said to have reached a depth of between eighty and ninety feet. Adjacent to the shaft very little of the bed rock is exposed, and since the shaft has been filled with rocks, an attempt to form at first hand, a conception of the character of the deposit, unfortunately must be restricted to a study of the loose material. It may be said, however, that from a study of the rock exposures in the vicinity, there is nothing to lead one to suspect the presence of an ore deposit of very appreciable size.

Upon the dump, small grains and crystals of pyrite are disseminated through much of the sericite schist. Very few fragments of ore are present. One of these showed that at some point within the shaft a vein, fourteen inches in width, about two-thirds of which was composed of pyrite and the remainder of quartz and sericite, traversed the schist parallel to its schistosity. Some of the ore has a remarkable brecciated appearance; small fragments of pyrite up to an inch across are closely packed within a matrix of quartz. Associated with the pyrite a few widely scattered particles of copper pyrites and galena were also visible. Other fragments showed portions of the same or of other veins of similar character, from one to four inches in width, enclosed within the schist. What was considered to be the best specimen of ore that could be selected from the dump yielded upon assay—Sulphur, 28.61 per cent; no copper, and 0.02 ounce of gold, and, 0.35 ounce of silver per ton.

About fifty years have passed since serious work was carried on in this shaft. Mr. John Smith who lives on lot 11, range VIII, informed me that about thirty years ago, prior to the shaft having been filled with rocks "the water was pumped out and a few drill holes were driven, but no blast was fired." According to him the bottom of shaft showed a width of about six feet of schists containing abundantly disseminated grains of pyrite and enclosing stringers of "solid pyrite." Mr. Smith agreed that the piece of ore, a record of the assay of which is given above, was in appearance "as good as could have been taken out of the shaft." Work in the shaft ceased because the copper content of the ore was very disappointing. Others who remember when work was being done on this property informed me that there was "very little, if any, copper in the ore." It does not seem reasonable to consider further the "Belvedere Copper Mine" as a definite source of copper. If further prospecting work is performed on the property, the aim should be to determine if there is sufficient low-grade pyrite to warrant the adoption of concentrating methods.

The Magog Mine, Range IX, Lot 11, Ascot.—"Yellow sulphuret in chloritic slate." (G.S.C. 1866, p. 308.)

This property is mentioned as one of the "thirteen mines" that "were operated" in Ascot Township prior to 1865—(R. W. Ells, in G.S.C. Vol. IV, 1888-89, p. 50k; also in G.S.C. Bulletin on Copper 1904, p. 46.)

Under this name it appears on the "Mining Map of the Township of Ascot" prepared by J. Obalski in 1908 when he was Superintendent of the Department of Mines of Quebec.

A careful examination of this lot did not lead to the discovery either of locations where prospecting work had been done, or of any indications that would suggest that such work should be done. Much of this lot is underlain by sericite schists, the metamorphic equivalents of quartz porphyry similar to that described from several of the properties in this township. From Mr. John Smith, who lives on the eastern portion of lot 11, range VIII, and also, from Mr. John McCaw, the Manager of the Ascot Mine, both of whom remember the early days in the prospecting for copper within this area, it was learned that no shaft was sunk on this property. "A little work was done in the form of trenches to bed rock but nothing of value was discovered." The trenches have been filled in and the stranger would not suspect that at any one time they existed somewhere opposite the Belvedere shaft (lot 10, range IX) within that portion of the lot now a hay-field.

Range X, Lot 1, Ascot.—On the eastern part of the western half of this lot, Mr. H. Astbury, during the past two years has made an opening, six to seven feet in depth in a lenticular vein of granular quartz of a dull to bluish-gray colour, enclosed within chlorite schists, striking N. 45° E., the dip of the hanging wall being about 45° while that of the footwall is 55° to 60°. The opening has been made where the vein attains, apparently, its maximum width of seven feet. Small veinlets of pyrite, less than an inch in width traverse the quartz, and these, together with small disseminated grains and crystals of the same mineral explain the rusty appearance of the quartz on weathered surfaces. A few widely scattered particles of copper pyrites may also be found in the vein. Indications do not offer any encouragement to renew prospecting operations at this point.

On the western quarter of this lot is a shaft, reported to have been sunk fifty to fifty-five years ago. It appears on the "Mining Map of Ascot," published in 1908, by J. Obalski, at that time the Superintendent of Mines for Quebec, under the name of the "*Massawippi*" mine. The shaft penetrates chlorite schists that, parallel to their schistosity, are traversed by a few irregular and small stringers of quartz. A few small grains of pyrite are present within some of the schist and may occasionally be found within some of the fragments of the quartz stringers. The shaft which is reported to have been twenty-five feet in depth, is now filled up with rocks. It seems quite needless to say that no ore was shipped from here nor may the discovery of an ore deposit be expected.

Range X, Lot 7, Ascot.—Upon the northwestern quarter of this lot a low knoll of schistose quartz porphyry rises. Close to the northern boundary of the lot and about 450 yards east of the road that crosses its northwestern corner, two openings have been made; one of which is situated at the foot of the knoll while the other, about fifteen yards removed to the south, is on the rising ground. Partially filled with debris, these shafts are now eight and nine feet in depth, respectively, and full of water. The light gray quartz-porphyry has been metamorphosed to sericite schists within which an abundance of the original quartz phenocrysts are visible, striking N. 40° E. and dipping 50° toward the southeast. The schists are traversed, parallel to their schistosity, by quartz stringers, one of which was observed to attain a width of eight inches. A few scattered grains of pyrite are present within these quartz veins, and within narrow bands of the schists. As a mining prospect, this occurrence is of no value.

Range XI, Lot 1, Ascot.—"Yellow and variegated sulphurets, with iron pyrites in green chloritic slate." (G.S.C. 1866, p. 308.)

Symbols indicating the presence of copper upon this lot appear both upon the map of the Eastern Townships accompanying Part J, Vol. VII, 1894 of the G.S.C., and on the Mining Map of Ascot Township published in 1908 by J. Obalski, then the Superintendent of the Department of Mines of Quebec.

In the southeastern portion of this lot, a hill rises from which an excellent view of the wide expanse of the surrounding country may be gained. Upon this hill, at a point about a hundred yards from the Hatley-Ascot line, and thirty yards from the line between ranges X and XI of Ascot, a shaft has been sunk in chlorite schists traversed by a few narrow stringers of quartz. These schists, the metamorphic equivalents of a fine-grained diorite or diabase, strike N. 65° W. and dip approximately 60° to the southeast. Mr. H. Astbury, who worked in this shaft, informed me that on the slope, it is ninety feet in depth; forty feet down, a drift extends about twenty-five feet to the southwest. A few small crystals and grains of pyrite are present in portions of the quartz stringers and in a very small percentage of the fragments of schists taken from the shaft. Although no copper-bearing mineral was observed to be present, Mr. Astbury stated that they found "a few specks of copper pyrites."

About thirty yards west of this shaft the chlorite schists enclose a lenticular vein of dark-gray granular quartz, containing disseminated grains of pyrite and traversed by irregular veinlets of milky quartz. Trenching to a depth of about two feet has shown this vein to be about thirty feet in length with a maximum width of three feet.

Fifty yards west of this trench, and ninety yards from the Hatley-Ascot line, a shaft has been sunk to a depth of eleven feet in chlorite schists containing a few small grains of pyrite.

About twenty-five yards farther west, a lenticular vein of dark-gray granular quartz, twenty-seven feet in length and four feet in width, contains some disseminated grains of pyrite.

A few yards southwest of this occurrence an opening has been made to a depth of four feet, where a band of the chlorite schists, up to seven inches in width, is impregnated with scattered grains of pyrite.

"Mr. Norton's Mines." Lots 2, 3 and 4, Range XI.—The properties commonly known under the above name, comprise lots, 2, 3 and 4 in range XI, Ascot, and are owned by Mr. A. O. Norton of Coaticook, Quebec. The names of the individual mines are—the *Suffield* (formerly known as the Griffiths) mine, the *Silver Star* (also known as the Bean or the Jackson) mine, and the *King* mine. The King is in reality the continuation of the workings of the old Howard mine (lot 5, range XI) on the adjacent lot (lot 4, range XI).

All of these mines are situated at or very close to the contact of sericite-schists with ottrelite or chloritoid-bearing chlorite schists. These schists strike N.E.-S.W. and dip at angles that vary from 10° to 40° toward the southeast. The light grey sericite schists, which are identical with those very commonly met with in the Ascot belt, are altered quartz porphyries. Abundant phenocrysts, up to one-fourth of an inch across, of quartz and of orthoclase and plagioclase are scattered through a finely crystallized base composed of the same minerals with sericite, chlorite and sparsely distributed, minute crystals of zircon. The chloritoid-bearing schists are, at least for the major part, highly altered sediments which Ells has mapped as being of Cambrian age. Although the exact contact between these two types of schists was not observed at any point on these properties it is quite certain, judging from relationships observed at other points, that the quartz porphyry is intrusive.

The ore-bodies along this contact and within the sericite schists near the contact are not as regular as at the Eustis and Capelton and other mines of the district, where they assume definite lenticular forms, sometimes of large proportions. Here bands or portions of the sericite schists have been much more irregularly replaced by a mixture of granular pyrite, chalcopyrite, galena and zinc blende. Although pyrite is by far the predominating mineral, galena and zinc blende are somewhat more abundant than in similar ores from other points in the Eastern Townships. The sulphides occur as disseminated grains along the planes of schistosity, or, as narrow intercalated seams or veinlets. Locally, along some irregular portions of the more schistose zones or bands, the schists have been quite completely replaced by the sulphides. The ore, especially of the King and Howard mines, frequently displays a banded appearance which still preserves the original crenulations of the schist that had developed prior to the replacement by the sulphides. Apparently the same waters that brought the sulphides, carried an iron-bearing carbonate and some quartz. In thin section under the microscope, the ore of most solid appearance that can be selected is found to contain considerable sericite, some chlorite, granular quartz and some of the carbonate. The sulphides have developed in the following order of crystallization—pyrite, zinc blende, galena and chalcopyrite. The silver values are more generally higher in these ores than in those of similar type from other localities; this is believed to be due to the greater percentage of galena present.

Since the sulphides were deposited, some faulting has taken place; these faults strike northwest to southeast and at least many of them have throws of only a few feet. Dark dykes, similar to those in the Eustis and Capelton mines, and of more recent date than the mineralization, traverse the schists, usually in a northwest to southeast direction. These dykes in this district, including monchiquites, camptonites and olivine-diabase, are very similar in their composition to rock-types that are common among the dyke rocks of Mount Royal and others of the Monteregian Hills. They are present in the workings of the Howard and of the King mines. One of these, a dyke of olivine-diabase, at the old mill-site of the Howard mine is shown in Plate II.

In terms of straight lines, these properties are about two miles distant from the Boston and Maine railway on the southeast, and about three miles from the Canadian Pacific railway on the west. Apart from small sample shipments, no ore has been sent to market from the Suffield and the King mines.

The literature pertaining to these mines and more detailed descriptions of them are now given:—

The Suffield Mine.—Range XI, Lots 2 and 3, Ascot.—"Near the summit of a hill, about 200 feet above the general level of the country, is situated the Griffiths mine on the third lot of the eleventh range of Ascot. The ore consists of the yellow sulphurets of copper and iron deposited through a breadth of between three and four feet in micaceous slate, which at this spot is much intersected with veins of quartz and calcspar, probably connected with some disturbance of the strata, as these, where the principal excavation has been made, take a sudden turn to the eastward, dipping north for about 100 paces on the strike, while the dip to the north and south of the turn is about E.<45°. The deepest part of the excavation is about twelve feet, and much of the ore, which has an average of three or four per cent of copper, lies in a gangue of quartz mingled with calcspar." (J. Richardson in G.S.C., 1886, p. 43.)

"Yellow sulphuret with iron pyrites in quartz and calcspar in micaceous and chloritic slate, making a great show of ore. This is the Griffith mine." (G.S.C., 1866, p. 308.)

"This mine, situated on the third lot of the thirteenth range of Ascot, is also the property of the Sherbrooke Mining and Smelting Company. A shaft has been sunk 200 feet; at the depths of eighty-five feet and 200 feet, levels have been driven to the east, the former 300 feet and the latter 100 feet connected by a ventilating winze. The amount of exposed ore is about 40,000 tons; 3,500 to 4,000 tons have been taken out and will be concentrated and smelted at the mine. Mr Stewart, the Company's obliging Superintendent informed me that with the present appliances they can take out seventy-five tons a day. The drilling is done by an air-compressor engine of sixty horse power. The drills which have a stroke of 3½ inches, and make 500 blows to the minute, penetrate eight feet in forty-five minutes.

The bulk of the ore is of a very fine texture, and varies in colour from a steel-gray to a pale yellow. It resembles portions of the Hartford mine ore described by Dr. Harrington as tetrahedrite. Iron pyrites is frequently associated with it both in granular masses and large cubes. Assays of ore made by John Massey & Co., London, England, gave silver varying from eight ounces to 235 ounces to the ton and from four to twenty-nine per cent metallic copper. Sixty men are employed at the mine." (Notes on some of the mines in Quebec, by C. W. Willimott, G.S.C., 1882, p. 2g.g.)

Ells repeats this information in the G.S.C., 1888-89, p. 55k; and in G.S.C. Bulletin on Copper, 1904.

Pl. IX

The Suffield mine, Range XI, lots 2 and 3, Ascot township.

In 1893, two specimens from the Suffield mine were assayed for gold and silver at the laboratory of the Geological Survey. One specimen described as "a white fine-grained, quartzo-feldspathic rock, through which was disseminated numerous fine particles of iron pyrites, copper pyrites and zinc-blende," yielded a trace of gold and 1.575 ounces of silver to the ton of 2,000 lbs. The other specimen, a quartzose chlorite schist through which was disseminated small quantities of iron-pyrites, zinc blende, copper pyrites and galena yielded a trace of gold, and 20.475 ounces of silver to the ton of 2,000 lbs. (G.S.C., Vol. VI, 1892-93, p. 46r.)

"I also visited the Suffield mine as I passed. It is the property of Colonel King but has been abandoned for a long time. The machinery is still there in pretty good condition, and includes a compressor of English manufacture. The buildings however are nearly in ruins. A little of the ore, raw and calcined, can be seen on the surface." (Report on the Mines of Quebec for 1898 by J. Obalski.)

"In the King and Suffield mines, the work carried on by the present proprietor, Mr. A. O. Norton, has been very successful. A large amount of ore has been exposed and important extensions of the work are being projected. (J. A. Dresser in "Copper Deposits of the Eastern Townships," G.S.C., 1906, p. 6.)

"At the Suffield mine, development work, which has been in progress for three years, was still going forward. Here a very large volume of low-grade, siliceous ore, pyrite and chalcopyrite, has been developed. This mine contains the largest amount of "developed" ore in the Eastern Townships; but no shipments have been made in recent years. The ore is rich in silica and alumina, the sulphides being finely disseminated through a schistose rock, consisting of quartz and sericite mica. For smelting purposes, it will prove very refractory. The ore is very low grade, and while concentration is possible, the losses will be large on account of the fine state of division of much of the sulphides. This ore also contains small values in gold, somewhat irregularly distributed; a small amount of silver is also found in many assays. Its value as a commercial ore under present conditions has yet to be proven. . . . The quantity of ore immediately available for stoping has not been estimated. The size and shape of the ore bodies is unknown, and the developed portions have not been systematically sampled since the development. The ore is rich in silica and alumina, is low grade, and will prove very difficult either to concentrate or smelt." (A. W. G. Wilson in Summary Report of the Mines Branch, Ottawa, for 1909, pp. 71 and 72.)

This mine was first worked under the name of the *Griffith* mine in the early sixties. It was later worked in 1882 and 1883 by the Sherbrooke Mining and Smelting Company. The old "Adams shaft" on lot 2, but quite close to the line between lots 2 and 3, is said to have been sunk to a depth of about 250 feet on the incline. Apparently in this older shaft which followed close to the contact, previously described, a body of quite solid sulphide ore was encountered; a small quantity of this ore may be seen in the old dumps. In the course of the older operations, at the ninety foot level, a curved drift was extended toward the south for about 300 feet. About fifty or sixty feet along this drift from the Adams shaft, a winze was also sunk on the incline to a depth of forty or more feet. At the time of my visit in September, 1914, the Adams shaft, below the ninety foot level, contained water.

Since work was resumed on this property in January, 1906, a new shaft has been sunk to encounter the ninety foot level of the old workings at a point approximately 200 feet from the old shaft. For about the first fifty feet, this shaft descends at an angle of 30° to 40°; but below this rapidly flattens out to about 15°. In November 1907, this shaft had a depth of about 200 feet. At present it has a depth, according to Mr. Norton, of about 400 feet. On the southern side of the shaft, drifts have been extended at the 200 and 300 foot levels of approximately 175 and 150 feet, respectively. On the northern side at the 250-foot level, there is a drift about 150 feet in length, and a raise has here been commenced with the intention of meeting the winze referred to above. At the bottom, the shaft has passed out of "the ore" and quite a long crooked drift has been extended on the northern side of the shaft with the hope of finding the continuation of the mineralized zone.

Mr. Norton informs me that he has been led to believe that between 200,000 and 250,000 tons of ore have been blocked out; and that "from hundreds of assays a fair average would be 3½ per cent of copper and some gold and silver." One sample of ore from near the winze yielded forty-two ounces of silver per ton.

All of this work has been done in the siliceous sericite schists. The work has followed a mineralized zone of irregular width, apparently not exceeding six or seven feet and usually less in thickness, that follows parallel to the schistosity for a length of somewhat more than 300 feet along the strike. Pyrite, associated with which there is a very much less amount of granular chalcopyrite and occasionally a little galena and zinc blende, occurs in the form of very irregularly disseminated minute grains and crystals. Quite as irregular in the mode of their occurrence are the parallel narrow stringers of these sulphides that, seldom more than small fractions of an inch in width, trend parallel to the schistosity. For short distances, these small stringers may be quite numerous, and then long intervals will follow in which very few or none of them are present.

Although development work has been carried along on a small scale for seven or eight years, no ore has been shipped. Since the closing of the King mine in 1910, work has been more vigorously prosecuted at the Suffield. Upon the outbreak of war, work was suspended, but the mine was being kept free of water. Very little of the ore in the recent workings approaches the better quality of ore taken from the property in the early days. The ore is of such low grade that the intention has been to erect a concentrating plant. Considering the character and quality of the mineralization, it will be a profound surprise to the writer if systematic sampling of what is now regarded as "blocked-out ore" would show the presence of an average of one per cent of copper. It is recognized that relatively small quantities of the ore may be selected that will carry several per cent. It is possible that work, if carried in other directions than along the zone that is now being followed, might reveal the presence of a better type of ore. Considering the property in its present state, it is incumbent that the continuity of the mineralized zone, upon which work has progressed, be more thoroughly established, and the possibility of economically concentrating the ore (without selecting minor portions of it) be demonstrated, before this property can be considered as a definite source that would contribute regularly to any copper smelter.

The Silver Star (*or The Bean*) *Mine. Range XI, Lot 4, Ascot.*—Under the name of the *Jackson* mine, lot 4, range XI, this property is described by Obalski in the Report on the Mines of Quebec for 1898, as follows:—"This mine was worked this summer by Messrs. Northern & Kennedy, probably representing the Rock Forest Gold Mining Co. On the occasion of my visit, the mine was provided with steam machinery and eight men were employed. A shaft of thirty feet had been sunk on a vein of variable thickness, ranging to four feet. The ore contained a heavy proportion of galena, a little copper, and certain specimens are said to have been very rich in silver. A specimen which I had assayed by Mr. Milton Hersey, gave seven and twelve ounces of silver and traces of gold, with a heavy percentage of lead. The ore offers certain analogies to a class of ores which has been worked in the same neighbourhood. Work has been going on since. Some ten tons had been shipped, and a few tons remained at the mine. The vein seems to be interrupted by a fault at the foot of the shaft. A little distance off another shaft of eighteen feet had been sunk, probably on the same vein, which runs in a northeasterly direction, by the Company which had worked the Howard mine. The vein again appears 600 feet to the southwest. This mine is at an elevation of 500 feet above the river."

About 125 yards from the northern boundary of this lot and 350 yards east of the road crossing its western end, a shaft has been sunk to a depth of sixty-five feet at the contact of the light gray sericite schists and the dark chlorite schists. It was through this prospect that Mr. A. O. Norton became interested in this group of mines.

No work has been done in this shaft for ten or more years. Mr. Norton states that a shipment of eleven tons of ore taken from the surface to about fifteen feet in depth, and sent to the Nichols Chemical Company at Capelton, netted $12.00 per ton above smelter charges. Specimens from here, when assayed, have yielded up to 12½ per cent of copper, 119 ounces of silver, and between $27.00 and $28.00 per ton, in gold. It is said that pieces of this ore have been found in which small particles of gold were visible to the naked eye.

At the time of my visit in August 1914, the shaft was full of water and only a very small quantity of ore scattered in the vicinity. Although the more solid ore from the shaft is composed chiefly of granular pyrite with some chalcopyrite, some specimens contain more granular galena and zinc blende than any of the similar ores from other localities in the townships. The lower portion of the shaft is not in ore, having passed into barren sericite schists. It is claimed that a slip was encountered and the "lost ore" has not been found. It is obvious that, at present, this shaft cannot be considered as a definite source of copper ore.

The King Mine.—Range XI, Lot 4, Ascot.—Since this property is the continuation of the workings of the old Howard mine, range XI, lot 5, it is advisable for the reader to first turn to the description of the latter that appears on the following page.

Concerning the King mine, A. W. G. Wilson writes:—"Active development ceased in 1910, and the workings have been allowed to become filled with water.

The ore body, which was mined on the Howard property extends into this property. It has been developed by an inclined shaft, and lateral drifts along the ore, but only some small trial shipments have been made. Portions of the ore are rich in copper, assays running as high as 12 per cent, and the property has been explored as a copper prospect, rather than as a source of pyrite. A small amount of pyrites containing considerable copper has already been developed ready for stoping.

As in the case of the Howard property, the size and nature of the ore lens already discovered would suggest that it might be profitable to search for other ore bodies below the present one. On which property they would occur is largely a matter of conjecture. Similar ore bodies have been found to a depth of over 3,000 feet on the Eustis property, and to over 1,800 feet at the Capelton mines; these mines are only a few miles away."

For six or seven years prior to 1910, prospecting work was done on this property by a small group of men, engaged by Mr. Norton. Since that time, the shaft has been filled with water. The drift from the Howard mine line to the King mine shaft is about 170 feet at a depth of seventy-five to eighty feet below the surface. The total depth of the King shaft is about 165 feet on an incline of 30° to 40°. Some drifts have also been extended for short distances. Mr. Norton informs me that assays show the presence of from one to ten dollars per ton in gold, from five to fifteen ounces in silver, and about five per cent of copper. About 1,000 tons of ore of very good quality has accumulated in the vicinity of the shaft. The intercalated stringers and ribbons of the sulphides in the sericite schist suggest strongly that the original vein of the Howard has not been found, but rather some irregularly distributed stringers, one of which, judging from fragments on the dump, locally attained a width of fifteen inches. In general the sulphides are present in the schists in the form of irregularly disseminated grains or as narrow stringers that, in a very haphazard manner, are distributed parallel to the schistosity. It seems highly probable that the same remarks that were made towards the close of the discussion of the Suffield mine, on the pages immediately preceding, may be appropriately applied to this property.

The Howard Mine. Range XI, Lot 5, Ascot.—"Yellow sulphuret in chloritic slate." (G.S.C., 1866, p. 308.)

"The Cillis (now the Howard) mine has within the last year been reopened to a greater depth, and the ore has been found to increase in quantity and quality so greatly that it is now considered an exceedingly valuable property. It has been purchased by an American syndicate, and will be worked." (G.S.C., 1888-89, p. 55k; also in G.S.C. Bulletin on Copper, 1904, p. 51.)

"At the Howard mine, a shaft of 200 feet shows a vein of nine to ten feet, while the extensive underground workings exhibit a large quantity of ore still standing." (Mines and Minerals of Quebec, 1889-90, p. 47, by J. Obalski.)

According to Mr. Obalski in the Report of the Commissioner of Crown Lands, Quebec, 1890, during the year ending June 30th, 1890, 500 tons of ore were shipped from this mine.

"Two new copper mines in the Sherbrooke belt of schists, the Moulton Hill and the Howard, have been opened up and are now shipping ore to a considerable extent. The ore is very similar to that found at the Capelton mines, and, like that, is used for the manufacture of sulphuric acid. The copper contents of the lode apparently increase as the veins or lodes are opened downward." (G.S.C., 1890, p. 46a.)

In the report of the G.S.C., Vol. V, 1891, p. 67s, it is stated that "at the Howard mine, the work has been largely of a developmental nature."

"The Howard and Moulton Hill mines have been worked on a large scale this year, being provided with complete plants, and the product was a large one. Operations will cease for the winter season at Moulton Hill. The mineral is forwarded to the United States." (J. Obalski in Report of the Commissioner of Crown Lands for the year ending June 30th, 1892, p. 77.)

"The Howard mine was in operation all last winter and is so yet." Rept. Comm. Crown Lands, Quebec, 1893.

"The Howard mine was worked to a slight extent with about twenty men for a short time lately; the works have reached a depth of about 350 feet." (Report of Comm. Crown Lands for year ending June 30th, 1894, Quebec, page 87.)

"The Howard mine and the Moulton Hill mines have been abandoned, and the machinery removed. From that portion of the Howard mine in lot 4, range XI, E½, the property of Colonel King, there was taken to the 19th March, 1895, a quantity of 1,348 tons of ore by the same Company." (J. Obalski in Report on the Mines of Quebec, 1898, p. 13.)

"After remaining unworked for a long interval, the property known as the Cillis mine, was reopened and operated by an American Company, and a large amount of valuable ore was produced. This mine, known under the new management as "the Howard" only ceased to be worked after the ore-body had been followed across the line into the adjoining property, called the King mine." (The Copper Deposits of the Eastern Townships, P.Q., by J. A. Dresser, G.S.C., 1906.)

Within forty-five yards of the southern boundary of lot 5, range XI, and approximately 550 yards to the east of the road that crosses the western half of this lot, the Howard shaft is situated at the contact between the light grey sericite schists and dark chlorite schists. In the sixties, this property was worked to a small extent as the *Cillis* mine. In 1889 it was reopened by the Grasselli Chemical Company of Cleveland, Ohio, who carried on extensive operations. A surveyed plan of the mine, prepared in April 1893 shows that the shaft had then reached a depth of about 300 feet on an incline to the southeast of about 35°. Northward from the shaft the underground workings extended to a maximum of about 240 feet; the longest drifts in this direction were about eighty-five feet below ground. Southward from the shaft, the workings extended to a maximum of about 320 feet; two drifts had crossed the southern boundary of the property at depths of about 75 and 110 feet to distances of about 180 and 110 feet respectively.

Considerable stoping had also been done; for forty or fifty feet northward from the shaft, above a depth of about 170 feet on the incline to within twenty to fifty feet of the surface; southward from the shaft, a much more extensive irregular stope had been developed above a depth on the incline of about 140 feet. The character of the underground workings shows plainly that much effort and capital was expended in searching for ore; in addition, some diamond drilling was done.

Southward from the shaft, the workings lie in the sericite schists; but northward they apparently extended into the chlorite schists for short distances. To the north of the shaft they encountered dykes of a much later age than the mineralization. Apparently the large dyke of olivine diabase shown in Plate No. II, accompanying this report, cut completely across this portion of the workings, intersecting the shaft at a depth of about 260 feet. Some slips or faults, striking toward the northwest and with hades of from 48° to 70° toward the northeast, were encountered.

Apparently, work progressed on a zone of schist, up to nine or ten feet in thickness, which in part was quite completely replaced by pyrite with much less chalcopyrite, a little galena and zinc blende. In large part, however, the ore consisted of ribbons of these sulphides irregularly intercalated with the schists. Much material now on the dumps shows that portions of the schists were impregnated with fine irregularly distributed grains of pyrite with a little chalcopyrite.

Detailed data concerning amount of ore shipped are not available. In the year ending June, 1890, 500 tons of ore were sent to market. Apparently the best period of production was during portions of 1891 and 1892. In 1894, only twenty men were at work for a portion of the time; and in 1895, the mine closed down. According to Mr. Obalski, up to March 19th, 1895, a quantity of 1,348 tons of ore was taken from that portion of the underground workings that had passed over into Colonel King's property on lot 4, range XI.

Mr. T. J. Grasselli of the Grasselli Chemical Co., kindly furnished the following memorandum:—"The Howard mine yielded a cupriferous pyrite running about thirty-five per cent Sulphur, from three to five per cent of Copper and seven to ten ounces of Silver, but in following up this deposit it ran out into small streaks, which made it unprofitable to operate." This statement undoubtedly expresses the conditions that were encountered with depth on the Howard property.

Mr. Grasselli also generously obtained the following statement from a gentleman who knew the property when it was in operation: "As I remember it, the tonnage taken out of the Howard mine was very small. My recollection is that black jack (zinc blende) became more abundant and that a slide was encountered, beyond which we were never able to pick up the continuation of the original vein. The opinion was formed that the continuation of this vein must have run off our property."

STOKE TOWNSHIP.

Range V, Lot 22 (a) & (b), Stoke.—This property was examined in August, 1914, and in May, 1915. A few weeks prior to my first visit, work was commenced, and a shaft had been sunk to a depth of nine feet on an irregular shear zone, traversing a fine-grained diorite. In general, the rock displays a tendency to schistosity, striking N 55° E, and dipping about 40° to the southeast; but at the shaft, the schistosity is more accentuated within a zone up to four feet in width. Within this zone and on the southwest wall of the shaft, a band, varying from a few inches up to a foot in width is quite well mineralized with pyrite and a few widely scattered grains of chalcopyrite; for two to three inches of this width, the schists have been almost completely replaced by these sulphides. On the northeast wall of the shaft, only scattered grains of pyrite are present in the chlorite schist. Upon following the schists in the direction of their strike, the narrow rusty patches, which mark the presence of disseminated grains of pyrite, are few and far between. In May, 1915, the shaft was full of water, and was said to possess a depth of about forty feet. No ore had been shipped from the property and the very small heap of so-called ore when compared with the dump of barren rock bears testimony to the statement that there are no indications that would justify the continuation of the work in the shaft.

CHAPTER IX.

COPPER DEPOSITS OF WEEDON AND STRATFORD TOWNSHIPS.

Weedon Township.

Following the discovery in 1909 of the well–known Weedon or McDonald mine on lot 22, range II, considerable prospecting work was done on adjacent lots, but as yet no other deposits of economic value have been discovered.

In August and September of 1913, all of the openings that had then been made on lots 1, 20 and 21 of range I, on lots 11, 12, 13, 14, 17, 18, 19, 20, and 21 of range II, and on lots 18, 20, and 23 of range III were visited by the writer. In the vast majority of instances, narrow rusty bands of schists, impregnated with a few grains or crystals of pyrite had attracted the attention of the prospector. Occasionally, work had been done on narrow quartz stringers, also containing a few grains of pyrite, that traverse the schists parallel to their schistosity. In some instances, a few small particles of chalcopyrite were observed to be associated with the scattered grains of pyrite both in the schists and in the veinlets of quartz. On lot 21 (c), range II, and on lot 23 (a), range III, very considerable diamond drilling has been done in the hope of finding "the continuation of the Weedon vein," but nothing of value has been discovered.

*The Weedon (or McDonald) Mine. *Range II, Lot 22, Weedon.*— This mine is situated about five miles northeastward from Weedon station (about forty miles from Sherbrooke) on the Quebec Central Railway. Upon the western slope of a ridge, it is about 700 feet above sea-level and 200 feet above the town of Weedon.

For more than twelve years prior to 1908, the very rusty appearance of the sericite schists, where the mine now is situated, had attracted the attention of men interested in mining. Because of the prevalent belief that these schists contained only disseminated particles of pyrite, no prospecting work had been done on the property. In the autumn of 1908, Mr. John McDonald of Sherbrooke, who has long been a keen and persistent prospector, and who had visited the locality "almost every year during the twelve years," purchased the land and the mineral rights. Under his direction, several small pits were sunk in the rusty schists. He informs me that "it was not until the latter part of August, 1909, when it came to me almost like an inspiration where the ore might be struck quickly." Abandoning the rock outcrops, he began to excavate in the bottom of a grass-covered depression elongated in a direction identical with the strike of the schists. The shaft 8 ft. x 8 ft. passed through three feet of earth, four feet of iron oxides and then penetrated solid cupriferous pyrite to a depth of about twenty feet. The property was leased under option to Dr. Pierre de Pierre Ricketts of New York, who later transferred it to the East Canada Smelting Company.

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*See an excellent paper on "The Weedon or McDonald Mine," by L. D. Adams (General Manager of the Weedon Mining Co.). Bulletin of the Canadian Mining Institute, February 1915, pp. 51-62.

According to the agreement of the option, this Company paid $100,000 to Mr. McDonald for the property.

Later work has shown that the grass-covered depression, in which the ore was discovered, roughly corresponds in outline to a horizontal section of the main ore-body of the mine. The schists, which enclose the ore-body, strike N. 35° E. with an average dip of about 45° toward the southeast. With depth, the dip varies from 25° to 60°, the ore-body conforming to the "rolls" of the schists. The hanging wall is of sericite schists, the metamorphic equivalent of a quartz porphyry. They are identical in every respect with the schists that enclose the bodies of ore at the Eustis, the Capelton and some other mines in the district. The foot wall is of chlorite schists, derived from the metamorphism of either a hypabyssal or volcanic rock of the character of either a diabase or porphyrite.

The accompanying sketch-map displays the general geological relations in the vicinity of the ore-body. Westward from the mine, one descends to lower land underlain by limestones and shales that are also striking northeast and dipping toward the southeast. The age of the sediments shown in the sketch was not determined, but from similar limestones on lot 17 (a), range III, fossils of Middle

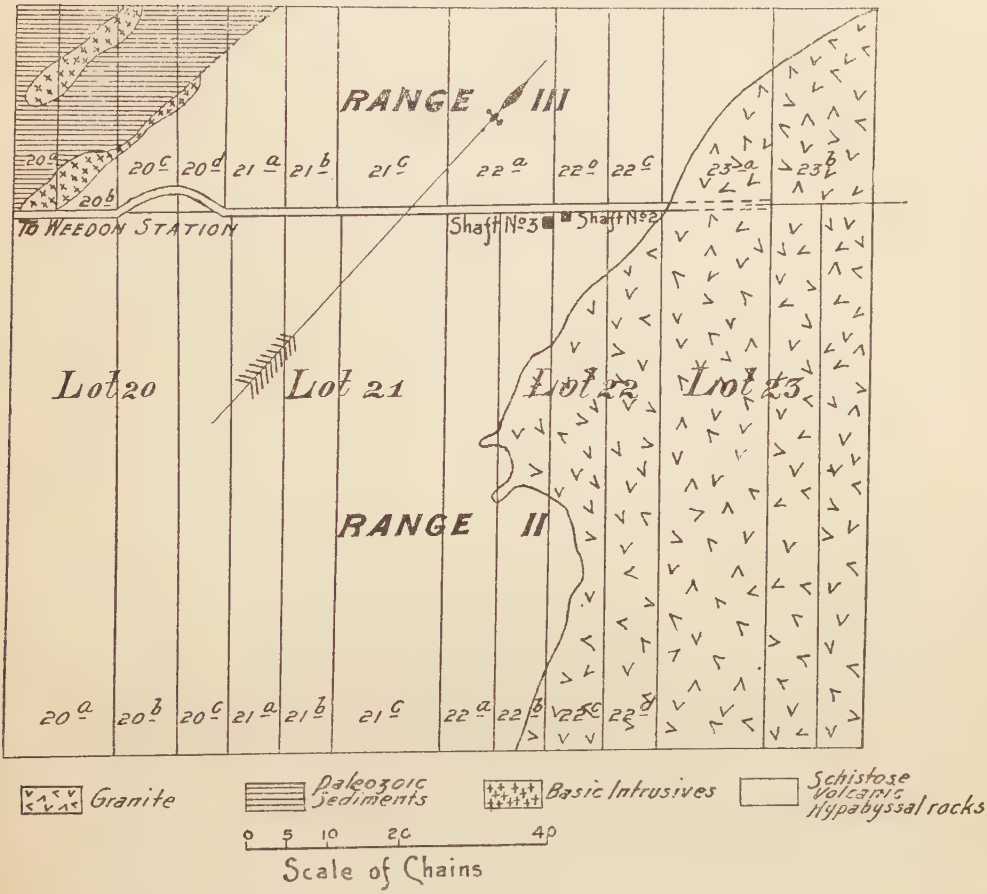

Fig. 9.—Geological sketch map of McDonald mine.

Silurian age were collected. The exact contact between the sedimentary rocks and the chlorite and sericite schists that form the ridge upon which the mine is situated was not observed. Irregular dyke-like intrusions, the rocks of which are now highly altered and in part schistose, but which originally must have varied in composition from a diabase to a pyroxenite traverse the limestones and shales. In one or two localities (as on lot 20 (a), range III, near the road to the mine) these basic intrusives are traversed by a few minute veinlets of very poor asbestos. It seems reasonable to suggest that these rocks were injected at the same time as the larger bodies of quite closely related petrographical character, which in other portions of the Eastern Townships have produced large quantities of commercial asbestos.

The ore-body is dipping towards the margin of a batholith of granite that occupies an area of at least fifteen or sixteen square miles, including portions of Weedon, Lingwick, Winslow and Stratford townships. The area underlain by the granite is characterized by prominent hills, that locally are referred to in a group as "the Block." Apparently this intrusive body of granite and its associated dykes constitute the youngest rocks in the vicinity. The margin of the granite batholith lies from 900 to 1,000 feet to the eastward of the shaft house, in a direction at right angles to the strike and that of the schists into which the granite is intrusive. For some distance from the contact, the granite here displays pegmatitic tendencies, being quite coarse, variable in grain and containing considerable muscovite, while the main portion of the mass is biotite-granite of uniform texture. Even where of normal granitoid character, muscovite is often more abundant toward the periphery than toward the interior of the intrusion. From what information that could be gathered from an examination of the exposures to the eastward of the mine that show the contact between the granite and the schists, it would appear that the line of junction between these rocks descends steeply. A diamond drill hole would soon determine their relation and contribute valuable information concerning the depth to which the ore-body extends. From the periphery of the batholith of granite a few dykes extend into the schists. A dyke of aplitic granite, about six inches in width, cutting the ore-body near its foot wall has been met with in the mine.

Of lenticular form, the main ore-body has been proved to have a length of somewhat more than 570 feet, and a maximum width of about fifty feet. It is the largest lens of cupriferous pyrite that has been discovered in the Eastern Townships. The foot wall of chlorite schists is more sharply defined than the hanging wall of sericite schists, within which, for a hundred feet or more from the ore, small grains and crystals of pyrite are very irregularly, though quite abundantly, distributed. Within the foot wall two bodies of ore,* of very much smaller dimensions, have been discovered. A few "horses" of schist, of small dimensions, have been encountered within the main vein, but one of the most striking features connected with the mine is the extremely small amount of waste rock that has to be handled; the result has been that only a very small dump has accumulated on the surface.

The ore is granular pyrite, with chalcopyrite, some pyrrhotite, scattered grains of zinc blende and a little galena. The last three minerals are of very subordinate importance in that they form but a relatively small percentage of the whole mass. Up to January, 1915, the ore shipped had averaged:—Copper, 3.62 per cent; Sulphur, 40.74 per cent; Iron, 35.86 per cent; Zinc, 0.77 per cent; Lead, trace; Insoluble, 12.2 per cent (Alumina, 4.08 per cent; Gold, 0.01 ounce; and Silver, 0.46 ounce. Mr. L. D. Adams, the General Manager, states that 7.5 cubic feet of the ore, in place, weighs 2,000 lbs. In a specimen of the ore examined in thin section under the microscope it was found that the metallic minerals have crystallized in the following order—pyrite, zinc blende, pyrrhotite and chalcopyrite. The pyrite is in the form of rounded grains or modified cubical crystals about which the other sulphides are distributed. Many of the grains of pyrite are traversed by minute cracks into some of which the pyrrhotite and the chalcopyrite extend. Even in what appears in the hand specimen to be solid ore is found, when examined in thin section, to contain some scattered grains of quartz and flakes of sericite and chlorite.

As at the Eustis and the Capelton mines, the copper values within the ore body have proved to be irregularly distributed. The chalcopyrite not only is irregularly disseminated, but, frequently, appears in narrow streaks or bands within the ore.

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*On the second level, some work was done on No. 2 vein which there lies about 10 feet within the footwall. It was found to be low grade pyrite carrying low values in copper. South of No. 3 shaft, two diamond drill holes, one on the 3rd and the other on the 5th level, were extended horizontally into the footwall for 102 feet and 80 feet respectively. On the 3rd level, No. 2 vein was encountered 20 feet within the footwall with a width of 20 feet (=a true thickness of about 14 feet); from assays made at intervals of 2½ feet it was found to contain an average of 0.55 per cent in copper. Here, No. 3 vein was penetrated at a horizontal distance of 82 feet from the main ore-body with a true thickness of about one foot and carrying about the same values in copper as the main vein. On the 5th level, at a distance of 3 feet in the footwall, the drill passed through eight feet of ore (believed to be vein No. 2), carrying slightly more than one per cent in copper, and met with a band of ore, one foot in true thickness (believed to be vein No. 3).

In general the copper content is somewhat higher in the vicinity of the foot-wall where in some places it has risen to from eight to twenty per cent. Locally, some of the ore near the hanging wall similarly carries a higher percentage in copper. The average copper content of the southwestern end of the deposit has been much lower than that of the ore from other portions of the mine.

Toward either end, the ore-body gradually narrows and then terminates in the form of a large number of stringers that dovetail into a slightly less schistose phase of the quartz-porphyry, quite heavily impregnated with small crystals and grains of pyrite. The stringers taper and fade into narrow bands of the schist which when followed along the strike are found to contain less and less disseminated pyrite.

The main ore-body has been formed by the replacement of the sericite schists. The narrow tongues or stringers of ore that at either end of the body extend into the less schistose phase of the quartz-porphyry, have been produced by replacement along very narrow shearing planes. Sericite schists, similar to those of the hanging wall, which are very schistose, have been readily and thoroughly replaced by the mineralizing solutions that, in rising, followed the contact between them and the more compact chlorite schists of the foot-wall. Although the ore from veins, No. 2 and No. 3, in the foot-wall were not examined, it is probable that they have been developed by the replacement of more schistose bands in the chlorite schists. Apparently the ore-bodies were developed either after or during the close of the period during which the rocks were rendered schistose. The schists are dipping towards the granite which truncates their schistosity. This suggests that the granite batholith invaded the district after, probably long after, the schistosity was developed in these rocks. During the summer of 1913, the first three weeks of the field work, upon which this report is based, were spent in studying the geology of the vicinity of both the Weedon and Stratford ore-bodies. At numerous points in the vicinity of their contact with the granite, the schists were observed to be very rusty because of the presence of disseminated grains of pyrite, occasionally with a few particles of chalcopyrite. The sedimentary rocks, in Stratford and Winslow townships, that appear on the existing geological map of the district as being of Cambro-Silurian age, were also observed to frequently contain scattered grains and crystals of pyrite when near the granite. In addition, both the Weedon and Stratford deposits are dipping towards the granite mass where the marginal facies of the granite displays pegmatitic tendencies. From these facts, the writer was led to conclude that the mineralizing solutions that formed the ore deposits emanated from the granite. In a more general study of the ore bodies of the Ascot belt, it was found that no granite occurs in the vicinity of any of the other large deposits, similar to those of Weedon and Stratford. Recently, within the Weedon mine, a dyke of aplitic granite, quite similar in character to some of the peripheral phases of the granite batholith has been encountered which cuts the lower portion of the ore-body. The aplite is fresh and apparently the only effect it has had upon the ore is to somewhat increase the copper values immediately adjacent to its contact; on the joint planes within the dyke thin films of chalcopyrite, with a little zinc blende and galena, have been deposited. The possibility arises that the ore-bodies were formed prior to the intrusion of the granite, but, if so, the heated waters and vapors attending the advance of the batholith have, to a minor degree, rearranged the sulphides previously within the sericite and chlorite schists.

In succession, work has progressed in three inclined shafts. The first or No. 1 shaft reached a depth of ninety-six feet; beneath it, the ore has been stoped. No. 2 shaft, situated 160 feet north of No. 1, was then sunk to a depth of 350 feet, penetrating the northern end of the main ore-body. To the north of No. 2 shaft, the ore extends for variable distances on the different levels, viz., on the first level, for 110 feet, on the fourth, for twenty-five feet. It would appear that with depth the ore-body is either slightly decreasing in length, or, in addition to the dip, it is plunging very gradually toward the southeast. No. 3 shaft, the one from which the ore is now raised, is sixty-five feet south of No. 1, and 470 feet in depth. Situated near the middle of the ore-body, No. 3 shaft occupies a most favourable position for the economical handling of the ore.

There are six levels which, within No. 3 shaft, are 85, 120, 230, 355, 415, and 455 feet respectively below the surface. With the exception of that portion of the ore-body to the south of No. 3 shaft where copper values are lower, the ore has been stoped down to the third level. The second level is the longest, having a length of 570 feet. Toward the south, the lower levels were extended until the average copper content proved to be less than 2.5 per cent; each of them have a length of about 400 feet.

About two hundred gallons of water, per minute, are pumped from the mine. More than a year ago, while sinking at a depth of fifty-four feet in a winze (6′ x 11′), on the fifth level, about ten feet north of No. 3 shaft, a drill hole encountered a fissure traversing the ore-body, from which water flowed under very considerable pressure. In a little over two hours, the winze filled with water. In May 1914, on the fifth level, three diamond drill holes were then put down, each with an inclination of about 45°, the average dip of the ore-body. Eighty-five feet south of No. 3 shaft, one of these holes penetrated 125 feet of ore, with an average copper content of 4.28 per cent before meeting the fissure. The second of these holes, thirty-six feet north of No. 3 shaft, passed through sixty-nine feet of ore, carrying on the average 2.83 per cent in copper, and met the fissure. The third drill hole, 115 feet north of No. 3 shaft, reached the fracture at a depth of thirty-eight feet, having pierced ore bearing 2.90 per cent in copper. From pipes inserted in these holes, the water was pumped to the surface. During the past month, a drift on the sixth level has broken through the water-bearing crack which apparently is striking north of west and dipping toward the southwest. In places, it proved to be an open crack, fractions of an inch in width. Along portions of its walls, the ore is beautifully slickensided. Locally, some small crystals of calcite have been deposited on the slickensided surfaces. Mr. L. D. Adams stated that when broken into, about ninety to one hundred gallons of water, per minute, were rising from the crack. The water probably derives its head from the hills to the east of the mine.

At first, the ore was taken by teams from the mine to Weedon station, a distance of five miles, at a cost of about eighty cents per ton. In 1912, a Bleichert aerial tramway, 19,500 feet in length was constructed from the mine to the railway at a cost of $1.75 per foot; the cost of transporting the ore to the railroad thus has been reduced to 6.7 cents per ton.*

On August 2, 1910, the first shipment of ore was made from this property, and during the balance of that year, 6,112 tons of ore were sent to market. Since then, the annual shipments of ore (in tons of 2,000 lbs.) have been:—in 1911, 23,700 tons; in 1912, 33,130 tons; in 1913, 52,000 tons; in 1914, 59,058 tons. Thus in the past five years, the mine has produced 174,000 tons of ore. From January 1st to May 1st, 1915, 30,000 tons of ore were shipped. The ore has been sold for $9.00 a ton, payment being made on copper and sulphur. Shipments are sent via the Quebec Central and Grand Trunk railways to Portland and from thence by steamer to New York, where distribution is made to various chemical works. From time to time, relatively very small quantities of the ore have been sent to the Nichols Chemical Works at Capelton.

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*For a detailed statement of mining costs see paper by L. D. Adams, Bulletin of Canadian Mining Institute, Feb., 1915.

The Weedon Mining Co., Limited, that formerly were carrying on the mining operations under a lease and bond from the East Canada Smelting Co., Limited, have recently purchased the property.

STRATFORD TOWNSHIP.

As a result of the interest aroused by the discovery of the Weedon mine, a promising lenticular body of pyrite was discovered, in 1910, on lot 8, range VI, S.W., of this township. This occurrence is about five miles in a straight line, to the northeast of the Weedon mine, and about 1,000 feet from the margin of the same batholith of granite, which is exposed to the north and east of the mine at Weedon. Up to the present time, 1,600 tons of pyrite, carrying from forty-five to forty-eight per cent of sulphur and a mere trace of copper, have been shipped from the Stratford deposit. Considerable prospecting has been done upon adjacent lots in this township, but, as yet, no other deposits of commercial value have been found. Detailed descriptions of these operations are now given:—

Ranges II and III, S.W., Stratford.—From Stratford post-office, a road extends to the northwest between ranges II and III, S.W., which gives access to a considerable number of these prospects. Lots 29 to 44 of these ranges are underlain by more or less schistose equivalents of fine-grained igneous rocks. The strike varies from N. 30° to 50° E. with dips of from 40° to 60° to the southeast. In these ranges, the following prospects were examined:—

Range II, S.W., Lot 36, Stratford.—About 300 yards from the road, a small opening has been made in sericite schists carrying a few grains of disseminated pyrite.

Range II, S.W., Lot 37, Stratford.—About 120 yards from the road, a shaft, reported to be twenty-four feet deep, has been sunk in chlorite schists, the metamorphic equivalent of an intrusive porphyrite. Striking N. 32° E. and dipping to the southeast, the schists enclose a few narrow stringers of quartz. A very few particles of pyrite are present in the schist. It is said that the shaft followed a "vein" of pyrite and chalcopyrite which in places attained a width of two inches. Upon the dump, no fragments can be found displaying any veinlets of these minerals.

Range II, S.W., Lot 38, Stratford.—About 350 yards from the road, and approximately 150 yards from the line between lots 38 and 39, an opening, four feet in depth, has been made in chlorite schists. A band of these schists, up to eight inches in width, contains scattered crystals of pyrite.

Approximately seventy yards to the east of this opening, one or two blasts have been discharged in an outcrop of chlorite schists. In a narrow and less-schistose band of the outcrop, a few fibres of bleached actinolite were mistaken, by the prospector, for commercial asbestos. In a small cavity in one of the quartz veinlets here enclosed within the schists, a few small crystals of epidote were observed.

Towards the back of this lot, about 125 yards from the line between ranges I and II, S.W., an opening has been made to a depth of four feet in a large lens of jasper-like quartz enclosed within chlorite schists. The southwestern end of the lens is exposed and it has been stripped toward the northeast for twenty-eight feet, displaying in this distance a maximum width of eight feet. Narrow bands of chlorite schist, a few inches in width, are enclosed within the jasperoid quartz. These bands of schist, as well as irregular portions of the jasper mass, contain abundant small octahedral crystals of magnetite, up to a fourth of an inch across. Although a few good specimens of magnetite may here be collected, it is very plain that the occurrence is not of the least economic value. Reticulating veinlets of milky quartz, containing a few flakes of specular iron ore, traverse the jasper. In appearance and mode of occurrence, this lenticular quartzose mass is quite similar to that (on range VI, lot 21, Ascot) near Sherbrooke.

Range II, S.W., Lot 39.—From three to four hundred yards from the road, a shaft has been sunk on a lenticular vein of grayish granular quartz in chlorite schists. The length of the vein has not been determined but in the shaft it is said to have possessed a maximum width of between two and three feet. In part, the granular quartz contains an abundance of very finely diffused particles of magnetite so arranged that they impart to the quartz a faint banded appearance, parallel to the N.E.–S.W. trend of the enclosing schists. Small irregular veins of pyrite and of milky quartz containing pyrite traverse the body of granular quartz. Some veinlets, up to two or three inches wide, are so nearly solid pyrite that some good specimens of ore may be collected. A very few grains of chalcopyrite occasionally are associated with the pyrite.

In September, 1913, the shaft was said to be about twenty-eight feet in depth. During the summer of 1914 the water was removed from the shaft and some further work done. Indications do not warrant the continuation of the work. Several properties in Ascot township, similar in type to this occurrence, have had very considerable work done upon them without any monetary return.

Range III, S.W., Lot 29, Stratford.—Near the middle of this lot, a few narrow stringers, of quartz with calcite, intersect limestones (of Middle Silurian (?) age) that are striking to the northeast and dipping steeply to the southeast. In one of the stringers, less than two inches in width, a very few grains of galena and zinc blende are present. A small opening has been made in the exposure. The contact between the limestones and the schistose volcanics, that occupy the southeastern portion of this lot, was not observed.

Range III, S.W., Lot 37, Stratford.—Three to four hundred yards from the road, two small openings have been made to depths of two and five feet in chlorite schists, traversed parallel to their schistosity by narrow stringers of quartz. A few grains of pyrite and small flakes of specular iron ore in the schist were responsible for this work being done.

Range III, S.W., Lot 38, Stratford.—Two small openings, (in each instance the result of the discharge of one or two small blasts of dynamite) have been made in sericite-chlorite schists traversed, parallel to their schistosity by numerous stringers of quartz with ankerite. In one of these openings, two minute veinlets of pyrite, each with a maximum width of one-fourth of an inch and not more than a foot in length, attracted the attention of the prospector; in the other opening, a very few scattered crystals of pyrite are present in the schist.

Range III, S.W., Lot 40, Stratford.—About 300 yards from the road, a shaft has been sunk in chlorite schists to a depth of fourteen feet. A few narrow quartz stringers trend parallel to the schistosity. Some small crystals and grains of pyrite are present in the quartz and also are disseminated along a few of the planes of schistosity.

The Stratford Pyrite Deposit.—Ranges VI and VII, comprising portions of Lots 6, 7, 8, and 9, Stratford.—About six miles to the east of the village of St. Gérard on the Quebec Central Railway, this property is situated on the summit of a hill which is probably 300 to 400 feet above the village. Its geological relations are shown by the accompanying sketch map, (Fig. 10.) The hill is composed of more or less schistose fine-grained igneous rocks, including both intrusive and volcanic types that in places are intersected by dykes of granite porphyry and spherulitic felsite that were injected during the advance of the batholith of granite, the margin of which is about 1,000 feet removed toward the southeast from the shaft on this property. The schists comprise both sericite and chlorite varieties, the former having been derived from the metamorphism of fine-grained quartz porphyry. Striking northeast to southwest, these schists dip from 45° to 55° to the southeast, toward the contact of the granite batholith. The schistosity was developed prior to the intrusion of the granite.

Locally, the schists on this hill are very rusty, because of the presence of disseminated particles of pyrite. As at the Weedon mine, a shallow depression, elongated in a direction corresponding to the strike of the schists, marks the position of the ore-body. The discovery of the deposit was facilitated by a forest fire that

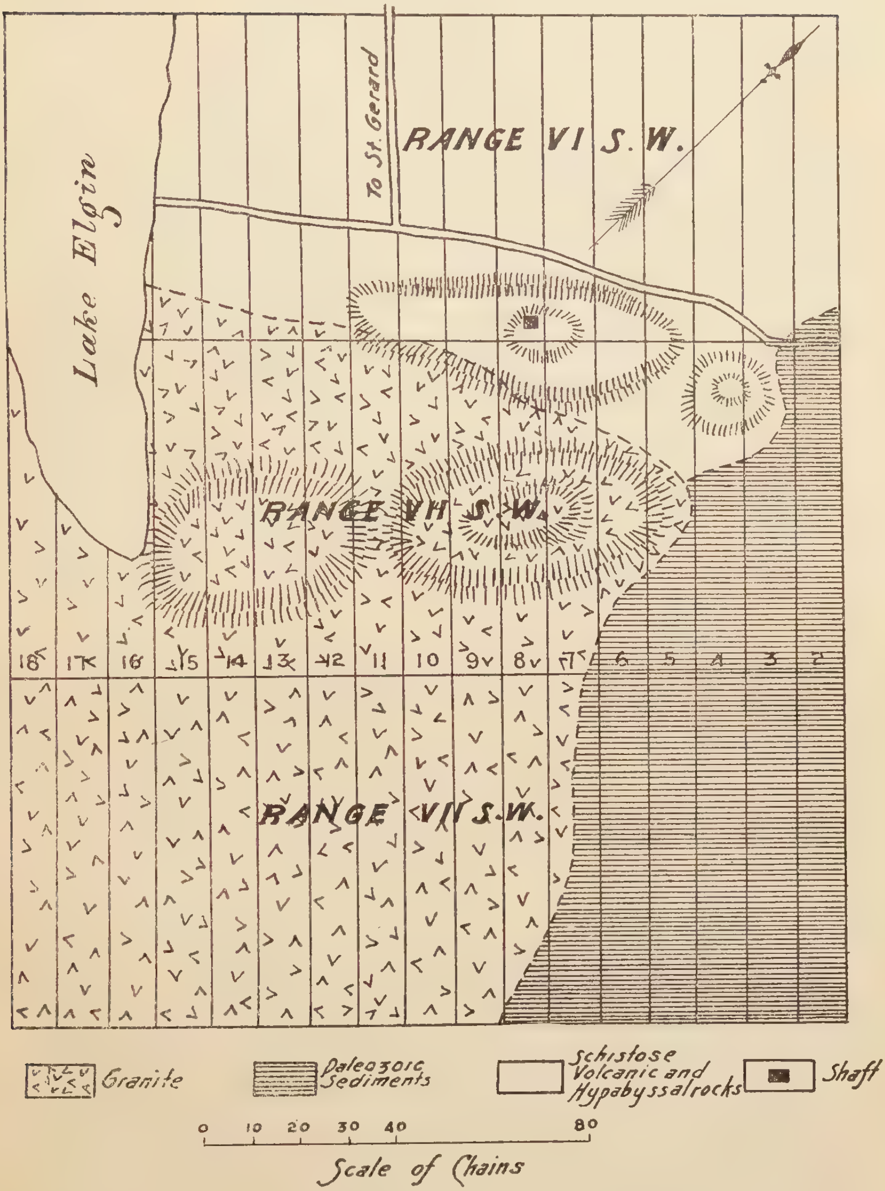

Fig. 10.—Geological sketch map of Stratford pyrite deposit.

swept the vegetation from the hill. The property is owned by a syndicate including Rev. Curé J. D. Bernier, of Stratford Centre, and others.

Discovered in 1910, as a result of the prospecting activity that followed the finding of the Weedon mine, an inclined shaft was then sunk to a depth of thirty-five to forty feet in the northeastern extremity of a lens of granular pyrite, carrying forty-five to forty-eight per cent in sulphur and a mere trace of copper and enclosed within sericite schists. This work was performed in six weeks by a Mr. Ralph Clark who was then managing superintendent at the Weedon mine. Later in 1910, under the direction of Mr. John M. Forbes of Montreal, a diamond drill was used in prospecting upon this property. Four of five holes were put down, to depths of about 120 feet and although it is reported that in some of them several feet of pyrite were encountered, the copper content of the ore was disappointing to those holding the property in lease at that time. In the most southerly of these boreholes, quite near to the boundary with lot 9, a few feet of pyrrhotite with pyrite and a little chalcopyrite was penetrated.

During the summer and autumn of 1914, the property was leased by Mr. P. E. Beaudoin of Thetford Mines, who holds the property under the imposing name of "La Mine de Cuivre et d'Or." The shaft has been enlarged and extended to a depth of about seventy-five feet. In September, 1914, at a depth of about fifty feet, they were commencing a drift toward the southwest. Prior to suspending work for the winter, about 1,600 tons of pyrite were shipped from the property. This work has corroborated the statement made in my preliminary report of last year that "In the shaft, the pyrite mass is five to six feet in thickness; if the shaft had been placed fifteen to twenty feet to the southwestward, and within the hollow which marks the strike of the ore-body, indications are that it would have penetrated a somewhat greater thickness of ore." At present, the southwestern wall of the enlarged shaft shows a thickness of from seven to ten feet of ore.

Surface indications, and the work that has already been done, suggest that upon this property two lenticular bodies of ore are now known to exist. The size and shape of the hollow near the shaft show that the lens now being worked will probably have a length of not more than eighty to ninety feet, and a maximum thickness at the surface of about twelve feet. An opening, situated several hundred feet to the southwest of the shaft and near the boundary of lot 9, has been sunk in similar sericite schists to a depth of four or five feet on a parallel lenticular vein of pyrrhotite with pyrite and a little chalcopyrite that at this depth does not exceed a foot or so in width. The bore hole previously referred to, intersecting this vein, probably at a depth of from sixty to seventy feet, shows that with depth it becomes a few feet in thickness and encloses a band of barren sericite schist. The ore-body upon which the main shaft is situated is high (40 to 48 per cent) in sulphur; the other which lies to the southwest, is chiefly pyrrhotite and hence much lower in sulphur, though, in so far as is known, it carries a very little copper. An assay of a specimen of the cupriferous pyrrhotite yielded 0.93 per cent of copper, 0.09 per cent of nickel and not a trace of gold. Their mode of occurrence suggests that with depth these ore-bodies will be in the form of lenses arranged *en échelon* and may be expected to occasionally enclose bands of barren schists, even as the workings of the similar, though many times larger, deposits of the Eustis and the Capelton mines.

The northern wall of the shaft shows that this lenticular body of ore terminates in that direction in the form of narrow tongues or stringers that are intercalated with the schists and that the intervening bands of schist are impregnated with grains and crystals of pyrite distributed along the planes of schistosity. Within a few feet to the northeast, these stringers taper to points and the schists become barren. In these as well as in all other features, this deposit is a much smaller edition of the Weedon, Eustis, etc., mines. The enclosing sericite schists are also of the same composition as at the Weedon, Moulton Hill, Eustis, Capelton, Suffield, etc., mines. Small phenocrysts of quartz, of plagioclase and orthoclase, are abundantly distributed through a fine-grained ground mass of the same minerals with much sericite, a little chlorite, some carbonate, and a few grains of pyrite. The ore itself contains a considerable amount of minute flakes of sericite and some grains of quartz.

An examination in thin section under the microscope of the cupriferous pyrrhotite from the smaller ore-body to the southwest of the shaft shows that even what, in the hand specimen, appears to be solid ore, contains much colorless hornblende; in the specimen examined, this hornblende comprises more than one-third of its volume.

On lot 7, range VI, two small openings have been made. One of these, about 100 yards from the line between ranges VI and VII, and about eighty yards from the boundary with lot 8, represents the result of a few small blasts discharged in schists that are rusty because of the presence of scattered particles of pyrite; here a few grains of chalcopyrite are said to have been found in a narrow quartz-stringer. Close to the boundary with lot 8, the other opening displays a band of schist, about a foot in width, impregnated with granular pyrite. Within two inches in width of this band, the pyrite grains are very abundant.

Range VI, S.W., Lots 10 and 11, Stratford.—Three small openings, none of which exceeded seven or eight feet in depth, had been made upon each of these lots. In each instance, work was done upon bands of schist impregnated with disseminated grains of pyrite; occasionally, a few particles of chalcopyrite have been found in some of these openings.

Range VIII, S.W., Lot 4, Stratford.—Upon the eastern side of the knoll that occupies the northern end of lot 4, within a few yards of its boundary with lot 3, a shaft has been sunk to a depth of eleven feet. Here a quartz vein, varying from a few inches to slightly more than a foot in width, and containing abundant though irregularly disseminated grains of pyrite, traverses sericite schists parallel to their schistosity. A few scattered grains and small crystals of pyrite are present in the adjacent schists.

On the northern slope of this knoll and close to the boundary with lot 5, an opening has been made to a depth of six feet in chlorite schists. A more schistose band, with a maximum width of four inches, is impregnated with a few grains of pyrite. Within this very narrow sheared zone, a few particles of chalcopyrite are also present.

On top of this knoll, and near the boundary with lot 5, a shaft has been sunk to a depth of eleven feet, on a rusty band, less than a foot in width, within which the schistosity is exceptionally well developed. Within this more schistose band, scattered grains of pyrite are present, and a few widely scattered particles of chalcopyrite may be found.

Range VII, S.W., Lot 5, Stratford.—West of the road that crosses the northern portion of this lot, a shaft was sunk, during the summer of 1914, to a depth of nine or ten feet in sericite schists containing scattered grains of pyrite.

Range VII, S.W., Lot 6, Stratford.—Close to the eastern side of the road that crosses the northern end of this lot, two openings, within about forty feet of each other, have been made to depths of about four and eight feet, respectively. Chlorite schists, striking N. 35° E. and dipping 50° to the southeast, contain scattered grains of pyrite. This is within a few feet or yards of the contact of the batholith of granite and the schists. A few feet from one of these openings a granite dyke, three feet in width, traverses the schists parallel to their schistosity.

Range VII, S.W., Lot 9, Stratford.—Close to the line between ranges VI and VII and within a few yards of their contact with the batholith of granite, an opening has been made in chlorite schists traversed by a few veinlets of quartz and impregnated with a few scattered grains of pyrite.

CHAPTER X.

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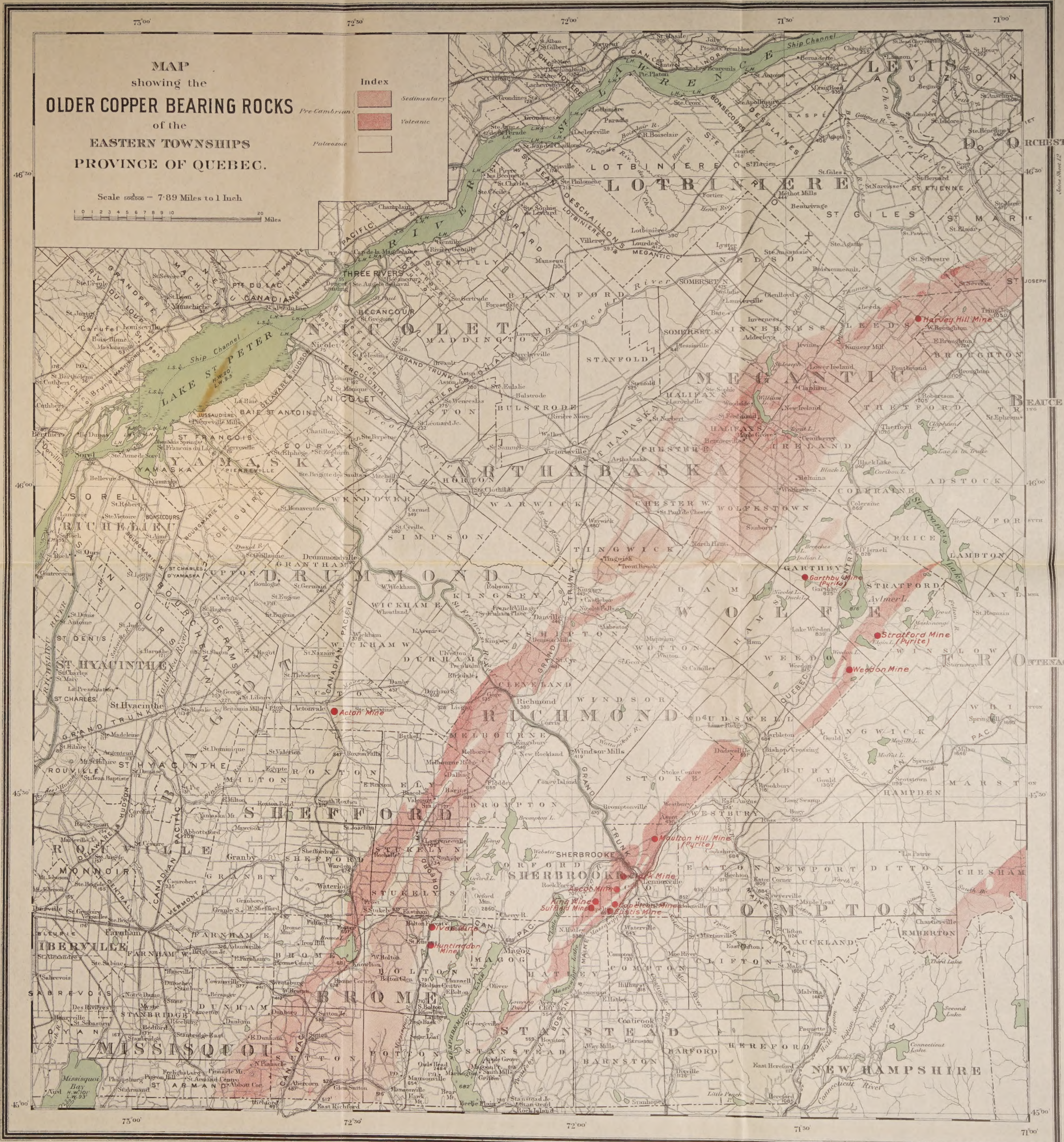

Base-map from plate, supplied by the Geographer's Branch, Department of the Interior, Ottawa.

With the exception of minor changes in portions of Weedon and Stratford townships, the geological boundaries have been taken from the map published by the Geological Survey of Canada to illustrate the Report on the Copper Deposits of the Eastern Townships by J. A. Dresser, M.A.

To accompany "Report on the Copper Deposits of the Eastern Townships", by J. A. Bancroft. 1915.

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